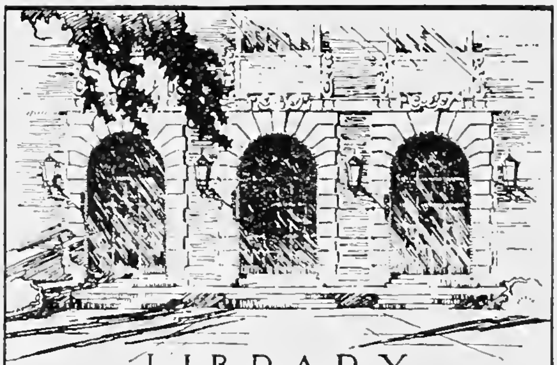

NSGA NATIONAL SAND AND GRAVEL ASSOCIATION

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900 Spring Street Silver Spring, Maryland 20910

Practical Operating Procedures For Progressive Rehabilitation Of Sand And Gravel Sites

By Craig Johnson
University of Illinois

UNIVERSITY OF ILLINOIS
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THIS RESEARCH PROJECT OF THE UNIVERSITY OF ILLINOIS WAS SPONSORED BY THE NATIONAL SAND & GRAVEL ASSOCIATION, SILVER SPRING, MARYLAND.

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Foreword

This publication is the second published report based upon the Research Program sponsored by the National Sand and Gravel Association at the Department of Landscape Architecture of the University of Illinois. The first report, "Simultaneous Excavation and Rehabilitation of Sand and Gravel Sites," by Anthony M. Bauer, was published one year ago, and the research for the third report is already underway.

The Research Program is sponsored by the Association through its Committee on Public Relations and is supervised by a Research Advisory Committee, the membership of which includes: Chairman: Wm. G. Carnes, Department of Landscape Architecture, University of Illinois; Cecil G. Cooley, Cooley Gravel Company, Arvada, Colo.; Kenneth L. Schellie, Schellie Associates, Indianapolis, Ind.; Walter I. Thieme, American Aggregates Corporation, Greenville, Ohio; Louis B. Wetmore, Deputy Commissioner, Department of Development & Planning, Chicago, Ill.; and Vincent P. Ahearn, Jr., Assistant Managing Director, National Sand and Gravel Association.

This report represents the conclusion of the second year of a four-year research plan. Industry and professional response to the results of this Research Program has been so universally favorable that a second four-year plan has been approved, to commence in September 1967.

While the research topics assigned for this first four-year plan have been general in scope, we believe that they have had specific and practical value to all members of the Association and to many professional landscape architects, land use planners, conservationists and others with a professional interest in the subject matter. This report, together with the first report and "Site Utilization and Rehabilitation Practices for Sand and Gravel Operations," by Kenneth L. Schellie, now provide a substantial beginning of a library of knowledge on the subject of rehabilitation of sand and gravel properties. In addition to the practical value of these reports, there has been additional value in the promotion of rehabilitation throughout the industry as evidenced by the increasing number of producers who are retaining professional landscape architects and planners on a permanent basis.

Research Advisory Committee

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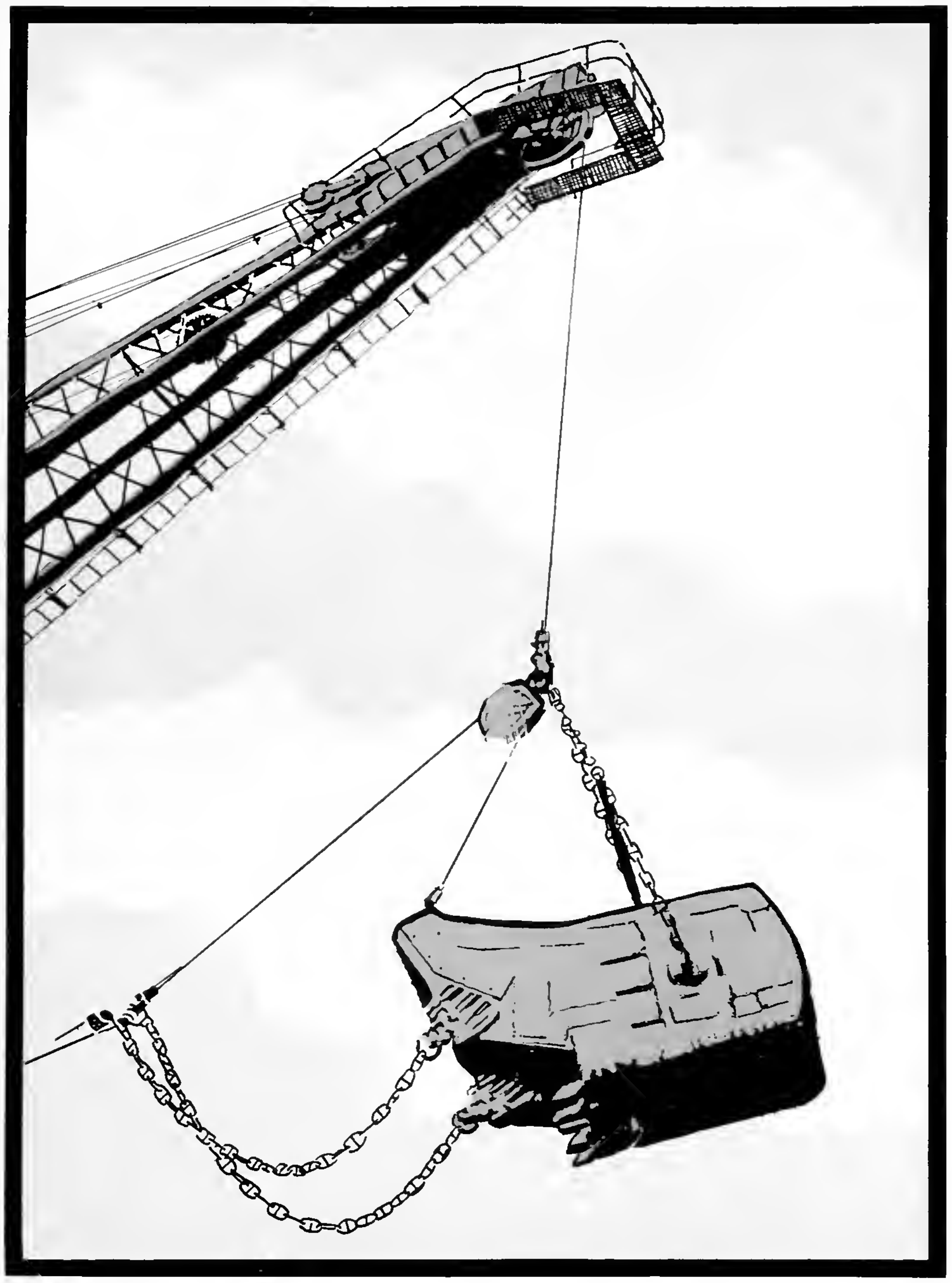
Preface

A wise conservation program should strike a balance between our needs of today and the needs of tomorrow. This does not mean that we are not to touch existing resources and are to leave them for future generations; but it does mean that unwise use and needless waste should be avoided, that every effort should be made to obtain the maximum benefits from the use of all our natural resources for the greatest number of people—now living or yet to live.

JOHN C. CALDWELL



Chapter 1

Introduction

"The processing of sand and gravel and rock—the basic aggregates of the construction industry is as old as civilization itself. Man's endeavor in this ancient respect has changed very little—only the quantities required and the equipment necessary for volume production have changed drastically."

From a Euclid publication.

Background

The population of the United States is expected to double by the year 2000 to roughly 350,000,000 people according to projections made by sociologists and census experts. These projections also note that the population will be concentrated in complex, technically oriented urban centers or chains of urban centers that are focalized at points of cultural, commercial, or industrial exchange. Current census information shows that 65% of today's population is centered in urban areas and the trend is toward an even higher percentage. The demand generated by these urban areas for building aggregates to construct roads, airstrips, bridges, dams, reservoirs, homes, building utility systems and many other facilities will place an increasing drain upon available sand and gravel resources. Already several states are beginning to notice a shortage of material to meet market demands.

Under present economic circumstances and transportation limitations, it is necessary for sand and gravel operations to exploit deposits near the market because sand and gravel is a bulky, low-cost product which can incur little increase in hauling distance from excavation site to consumer without a prohibitive increase in product cost.

Thus it would not be economically feasible to transport

Fig. 1 — The Mining Environment

sand and gravel from rural Minnesota to meet the needs of Newark, New Jersey. Consequently most sand and gravel operators have gravitated to those as yet unbuilt upon deposits near the periphery of urban centers in an effort to satisfy the demand for their product. Today 75% of all sand and gravel operations are located within this urban-suburban zone area of development. (FIG. 2.)

Problems

The necessity to operate near the market area has placed the sand and gravel industry, a mining operation, in direct competition for sites with the immediate and more glamorous proposals for urban development such as residential subdivisons, commerial centers, industrial complexes and public open-spaces, to mention a few. In light of past operating practices, attempts by sand and gravel producers to secure a mining permit, special use permit, or zoning ordinance change to allow the excavation of sand and gravel on these sites are frequently rejected, and other types of development are rapidly covering the dwindling sand and gravel resources. The underlying reason behind much of the unwillingness on the part of communities to accommodate sand and gravel operations within their area of jurisdiction stems from an assumption, often erroneous that a sand and gravel operation is inherently a noisy, dusty, incompatible land use which creates unsightly and unusable blemishes in the landscape and does not contribute toward the welfare of the community.

Opportunities

"The sand and gravel industry is in a unique situation insofar as rehabilitation is concerned. It utilizes heavy earth moving equipment, and often has large volumes of material, unsuitable for processing, available for creating functional land forms. Since it is necessary to move this material in order to extract the desired natural resources, it becomes a matter of manipulating the equipment in a manner that will achieve the most desirable land areas.

Also, the location of the operation offers unique opportunities in land development. Not only are land values higher with numerous uses vying for a piece of land in the area in which operations exist, but the results of the excavation process may create unique features, such as large bodies of water that might not otherwise be available for development.

*A financial gain is naturally one of the basic objectives of a rehabilitation program. A substantial gain has been realized in many of the existing projects. However, there are such intangible benefits as good will and community acceptance that will open the door for further development of otherwise inaccessible deposits."**

Objectives

In the face of mushrooming population and the subsequent demands for land for all types of public and private urban development, the sand and gravel industry is beginning to realize that the rehabilitation of depleted sand and gravel sites is becoming as important as the extraction of sand and gravel. The sand and gravel industry must now perform a dual function: The production of sand and gravel and the creation of usable land areas.

The hypothesis upon which this research is based is that sand and gravel operations can be effectively planned (1) for the reduction of inherent noise, dust, and visual disorder and (2) for the development of an optimum, practical and esthetic use for the site after operations have been terminated. Land development can occur simultaneously with excavation without reducing the efficiency of either operation.

The two specific objectives of this report are (1) illustrate how sand and gravel operations, performed by standard types of equipment, can be conducted in an orderly non-objectionable manner and (2) illustrate methods for utilizing equipment and operation potential to progressively create usable and esthetically pleasing land forms during the course of the extractive operations.

Research Method

The execution of this study was organized as follows:

1. Survey

A variety of surveying techniques were utilized to become acquainted with and obtain an insight into the sand and gravel industry, its rehabilitation problems and potentials.

Collecting and recording basic data obtained by reviewing pertinent literature was the first method. Three survey areas were outlined:

- A. Deposit and resource information.
  1. Geological information
  2. Hydrology data
  3. Test boring analysis discussions
- B. Information directly associated with the sand and gravel industry's operations and equipment.
  1. Operational procedure
  2. Equipment rehabilitation capabilities and limitations
  3. Characteristic, excavation created land forms
- C. Site planning information related to mining site rehabilitation.
  1. Review of current information on coal, iron, phosphorus and other mining industries rehabilitation practices
  2. Reviews of all NSGA publications

A field reconnaissance was conducted of 24 mining sites in Illinois, Indiana, Colorado, Maryland, Virginia, New Jersey and New York. The primary aims of such field reviews were to

*A quotation from *"Simultaneous Excavation And Rehabilitation Of Sand And Gravel Sites"* by Anthony M. Bauer.

Fig. 2 — Pit in the Path of Urban Development

obtain a realistic background and understanding of the scale of various types of sand and gravel operations, and of their visual, functional, and ecological influences upon the landscape. Numerous aerial and eye level photographs were taken to record the findings for future reference use. Attention was also given to the conventional uses of equipment in performing normal extractive and rehabilitation operations. This was to determine potential of equipment in the development of depleted sites.

2. Analysis

All information was recorded and combined in written, graphic, and photographic form. Assembled, it provided a perspective of the sand and gravel industry's role in rehabilitation, determined exactly what development problems existed, their causes, and pointed out the rehabilitation potential with the use of equipment during normal operation.

3. Deduction

On the basis of a survey and analysis of site, equipment and operation recommendations for the application of equipment to solve development problems and meeting rehabilitation objectives were formulated.

Hopefully, this report will be as helpful as others have been in encouraging the development of rehabilitation programs. Reports in themselves do not remove operational nuisance problems, nor create usable land and water bodies. Neither do reports improve the appearance of landscapes physically scarred by sand and gravel operations. Solutions to these problems only result from the initiative exercised by each producer in organizing and implementing a rehabilitation program. These challenges have been definite assets to the community, while bringing credit to the sand and gravel industry (FIG. 3.) Cases of complete site rehabilitation must become the rule rather than the exception if the industry is to make a widespread contribution to an improved American scene, and if it is to improve its national image as an industry.

One case study was developed to test the conclusions and demonstrate the feasibility of recommendations.

Summary of Findings:

Practical Operating Procedures For Progressive Rehabilitation of Sand and Gravel Sites

Each operational step contributes in its own way to the production of sand and gravel and each step also offers opportunities for site development. Clearing affords an opportunity to selectively clear the site, thus conserving vegetation anywhere that it will not interfere with extractive operations. Stripping and stockpiling operations may provide hundreds of thousands of cubic yards of unusable material for a variety of land forming purposes. Excavation affords the opportunity of creatively molding the site to meet the topographic requirements of the previously determined land use, so that it can be economically and visually adapted to the site.

The types of equipment that perform the various operations comprise the tools that are used for the extraction of sand and gravel and can be used simultaneously for site rehabilitation. Each particular type of equipment is designed to perform a certain extractive operation or sequence of operations and each has a pattern of operation within which it operates most efficiently. All types of equipment possess capabilities for rehabilitation. Ideally, the most efficient way to capitalize upon these capabilities is to utilize the equipment for rehabilitation while it is in the extractive operation. There are two reasons:

Fig. 3 — Rehabilitated Site

1. Equipment is used for the excavation of sand and gravel while it is achieving site development objectives.
2. Equipment operating patterns can be organized efficiently so that rehabilitation is accomplished within the framework of normal operating patterns; thus, production efficiency is not sacrificed for rehabilitation.

The contents of this report are a detailed elaboration upon these general findings.

Simultaneous Excavation And Rehabilitation Of Sand And Gravel Sites

by Anthony M. Bauer

The sand and gravel industry is in a unique position to contribute to the growth and development of the nation. Not only does it process a basic resource essential to the construction industry, but it contains resources and potentials within the sphere of its activities that provide highly favorable opportunities for molding the excavated lands into real estate that is an asset to both the producer and the community. Three typical characteristics of the industry that contribute most to the development potentials of a sand and gravel site are:

1. Material unsuitable for processing
2. Heavy earth moving equipment
3. Location—in relation to the urban environment

Current rehabilitation practices are primarily directed toward improving the conditions created by the excavation process. A number of these sites contain successful land use projects. Often the fullest potential was not achieved, with various unusable land and water areas resulting. In addition, minimum effort was being directed toward improving the appearance and reducing the conflict of the plant and excavation area during the life of the operation. The established undesirable image of the industry is thus perpetuated.

There are several factors that limit or deter rehabilitation activity. These factors must be dealt with before a plan for development is formulated if the industry is to cope satisfactorily with the obstacles they present. The most significant of these are:

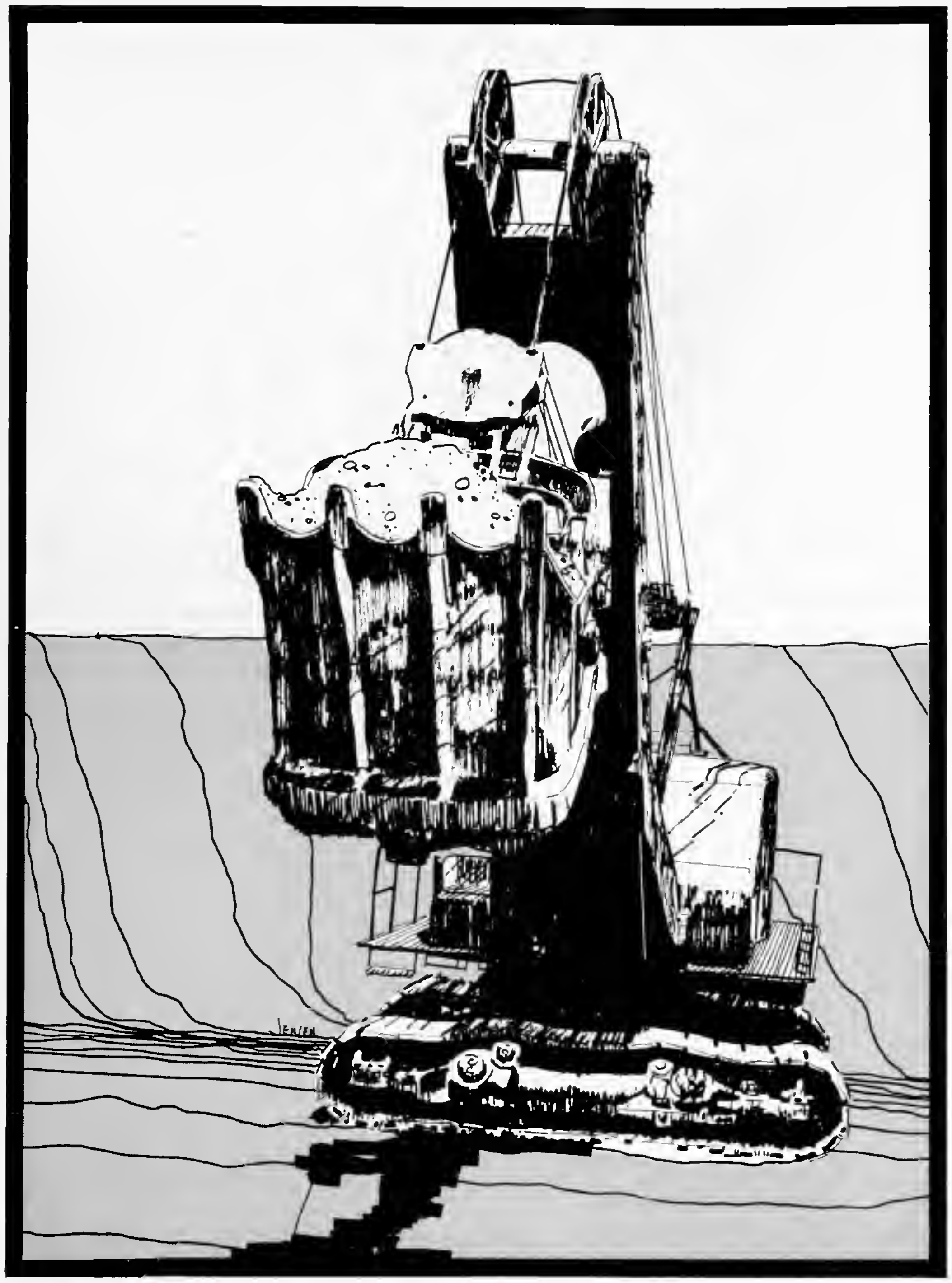
1. Low land values.
2. Lack of suitable grading and earth moving equipment.
3. Extensive and dramatic pit conditions.
4. Ownership.
5. Separation of rehabilitation and excavation operations.

Development of the ultimate land use potential of a sand and gravel site requires an organized planning program to correlate site, operational, and environmental factors with a concurrent excavation and development process. The proposals and subsequent development procedures are based on the character and structure of the site, the capabilities of the equipment, and the influences of the environment, utilizing the assets and reducing the conflicts of the total activity. Information about these influencing factors is essential in identifying the most effective approaches to land development. The detail of this information will determine the success of the plans.

Following is a brief summation of a planned approach to the development of a sand and gravel site:

1. Initiate the planning program upon purchase of sand and gravel property.
2. Review information pertinent to planning decisions about the:
   a. Deposit
   b. Operation and equipment
   c. Environment
3. Screen any anticipated objectionable characteristics.
4. On the basis of the above information determine appropriate land use and land patterns.
5. Integrate the development of these land patterns with the excavation process.
6. Improve the general appearance of the plant area.
7. Progressively develop the proposed land use potentials.

In addition to creating functional land areas, a development program should improve the physical appearance of the plant thereby making the operation more compatible with the surrounding land use. These two objectives can be accomplished because the capacity for land development and improvement of physical conditions is contained within the site, the operations and the surrounding environment. Planned development exploits this capacity.



Chapter 2

Equipment, Operations and Proposals

Section 1: BACKGROUND

Equipment Evolution

Looking at the evolution of earth moving equipment and its role in performing sand and gravel operations, it seems that only yesterday a producer's inventory of equipment included, a team of horses, a Fresno bucket, a fleet of wagons, and a dozen hand shovels. These simple tools were adequate to satisfy a young America's limited demands for construction materials in the mid 1800's. Little thought was given to the use of equipment or operation for developing the excavated sites because land ethics were still clothed in the pioneer spirit in which nature was an element to be exploited and resources were limitless. There was no public pressure for rehabilitation because unspoiled land was abundant and urban development

simply avoided surrounding mining operations, industrial districts, and railroad yards. By 1900 America was prospering, its cities were growing, and its citizens demanded a better living environment. From these growing pains, pressure was transmitted to heavy equipment manufacturers by sand and gravel producers, industrial builders and large construction companies. Old equipment and methods of operations were slow, cumbersome, and inadequate to keep pace with the growing need for dams, bridges, roads, homes, and commercial buildings. The construction and mining industries demanded bigger, faster, and more efficient machinery to cope with new and more complex extraction and construction problems.

One of the first mechanized monsters was the custom made boiler plated steam shovel which hissed and boiled ominously as its half yard bucket systematically scooped out sand and gravel. This was immediately succeeded by the streamlined, gas-engine, shovel. The most rapid period of development in the evolution of earth moving equipment occurred between 1935 and 1945, when the armed forces required better types of earthmoving equipment to construct bases throughout America. This period ushered in the dump truck, the crawler dozer, and the rubber tired scraper to complete the modern cast of earthmoving characters.

The continuous evolution of earth moving equipment will play a lead role in bringing into realization the growth and development of America as it rapidly progresses toward doubling its living, working, and recreation facilities in the next 35 years. Today, modern equipment, huge trucks with 50 ton capacities, draglines that can hog 90 yards of material in one cast, and scrapers that can strip 35 yards of material in less than a minute, can move material faster, farther, more cheaply and with less waste than ever before. They have opened the door to resource deposits that were formerly listed as unminable and have made rehabilitation feasible on sites where it would have been considered impossible by conventional methods.

Pressure for land around urban centers, a growing public awareness of the functional and esthetic values of the landscape, and imaginative conservation thinking are events which have paralleled the evolution of earthmoving equipment. The White House Conference on National Beauty was an expression of these concerns and an effort at the national level to bring the entire resource picture into focus. From the discussion it became obvious that Americans can no longer look, as the pioneer did, at the limitless resources of this vast country. Open space, wilderness areas, sand, gravel, were discussed as a few of our resources that are dwindling rapidly. These and many other areas will require immediate attention if resources are to be put to their optimum use.

The increasing, complex problems of resource development have placed new responsibilities on the sand and gravel producer, for he is an extractor of resources and a potential developer of buildable land forms. It falls on his shoulders to utilize his operational potential and the tremendous possibilities of modern earth moving equipment to extract the sand and gravel without waste and develop the excavated site in such a manner that it can be put to the highest and best use possible, for future generations, after excavation is completed.

Introduction to Operations

Every sand and gravel operation is a unique developmen resulting from a variety of site, equipment, and environmenta characteristics. Composition, quality and quantity of material market desired, plant capacity, topography and zoning are som of the rudimentary factors that contribute to operational individuality during the excavation sequence.

The diversity of methods for performing sand and grave operations is perhaps analogous to the variety of batting stance among baseball players: There are as many batting stances o methods of operation as there are batters, or producers. But when differences in site, deposit, and personal equipment ar removed, most operations like the swing of the batter will include the same sequence of motions, or more appropriately, th basic operation steps; which would include:

clearing	stockpiling	transporting
stripping	excavating	processing

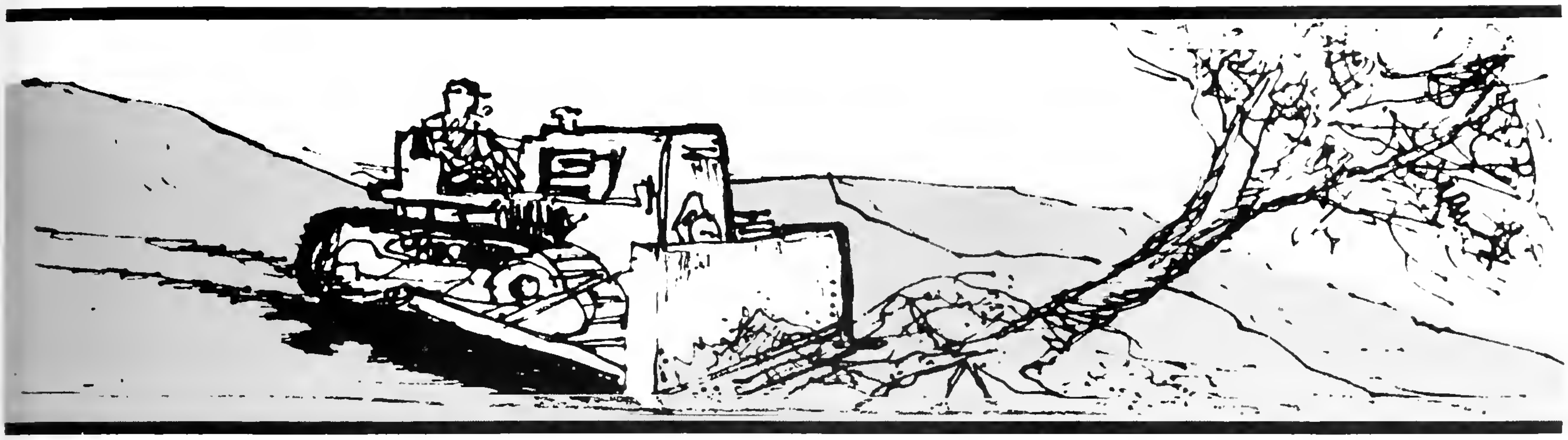
In most cases today's producers have an operating pla that co-ordinates the use of equipment in all these steps in a effort to direct the flow of sand and gravel from the excavatio site to the processing plant in the most efficient manner. Th purpose of an operations plan is to gain the maximum outpu from men and machines, to produce quality aggregates profitably, and to sell these construction materials to the consume at the lowest possible cost.

Unfortunately, the operations plan, in itself, does not contribute significantly toward site development. But, it can if it scope is broadened! Consider the definition of "planned development" taken from "Simultaneous Excavation and Rehabilitation of Sand and Gravel Sites": "Planned development is process of arranging the possibilities that evolve from the site the operation, the equipment and the environment that wil eliminate the creation of unusable land areas and reduce inherent operational problems." This implies that operation an equipment receive a second look. It suggests that we not onl consider what each operational step or use of equipment doe to carry on production of sand and gravel but also what problems it creates, what development opportunities it possesses and what it contributes visually and physically to the environment. In essence a rehabilitation plan is a propose sequence of operations, (an operations plan) for the esthetic of the community, proposed land-use, and the owners operational capabilities and sequence.

This chapter is an inventory and analysis of equipment an normal operating procedures. The purpose is to illuminate thei individual roles in the extractive process and their potentia for progressive rehabilitation.

The chapter is structured in the following manner:

1. Description of the operation
2. Analysis of the operation results inter-related to rehabilitation
3. Rehabilitation potential of equipment & operations
4. Proposals for use of equipment and operation potential to progressively develop the site



Section 2: CLEARING

Description

Clearing the site prior to excavation involves the removal of trees, shrubs, boulders, and structures thus allowing equipment to move freely over and into the earth's surface in the performance of the excavation operations. The bulldozer is the most commonly used type of equipment for the clearing operation.

Results of Operation

Visual Impact:

Clearing operations remove the vegetation which formerly screened the site and linked it with the surrounding landscape, thus creating the first visually negative impression of a sand and gravel operation. The impact of clearing depends upon several factors: the amount and type of vegetation removed, the size of the cleared area, the percentage of the site cleared at one time, and the landscape character of the area. For example, the removal of one or two small trees on a prairie sand and gravel site will be noticed only by those intimately familiar with the area. By contrast, the removal of 400 acres of mature trees from a densely forested site in one operation will generally create a drastic contrast with the surrounding landscape which can be readily seen by passing viewers. (FIG. 4 & FIG. 5)

Ecological Change:

Micro-climatic alterations both on and off the site caused by clearing operations disturbing nature's balance and thus create ecological change. The severity of the disturbance is greatest on sites where the amount of clearing is extensive. Significant micro-climatic elements that change include wind velocities, light levels and rain penetration. These alterations may seem academic in comparison with the drastic changes that excavation phases of sand and gravel operations impart to the landscape.

However, in many cases the initial disturbance caused by clearing has direct bearing upon site rehabilitation, particularly preservation of existing plant materials for screening and development purposes. As an illustration, consider an optimum change situation. A large site that is densely forested with pine trees. Prior to clearing these plants formed their own competitive but self-sustaining and mutually protective society. When clearing operations began the balance in the society was disrupted. Low growing trees, when removed from the edge of the site, no longer break the force of erosive winds. Thus, what were once normal winds, in the crowns of these trees, now have the potential to blow trees down and cause extensive damage both on and off the site. Increased light, which floods the newly cleared opening, spells doom for the shade loving

Fig. 4 — Site Before Clearing

Fig. 5 — Site After Clearing

Fig. 6 — Wasted Timber Resources

Fig. 7 — Screening Benefits of Conserved Vegetation

plants that live under the forest canopy. The total effect o these environmental changes on the vegetation to be remove in the excavation area does not really matter but advers affects on areas that were to be conserved for screening or a amenities for later site development may be both economicall and esthetically serious. It would require large sums of mone to replace the screening with other plants and the screenin effect of new planting will be unsatisfactory until the plant begin to mature.

Waste:

Some thought should be given to possible ways to use th timber that will be removed as a result of clearing. The nor mal practice (burning it) destroys any possibility the timbe may have had for pulp products, lumber, crating material o firewood and in fact may be prohibited by atmospheric contro laws. Thousands of dollars in wood resources annually go u in smoke on sites where substantial numbers of large tree are removed and disposed of carelessly. (FIG. 6)

Rehabilitation Potential

The altered landscape, as a product of clearing operations will become more foreign in appearance as excavation opera tion progresses, making the visual and environmental change created by clearing seem minimal.

If clearing procedures and equipment were oriented towar selective clearing to conserve the screening potential of existin plant materials where possible, the harsh appearance of suc ceeding operations would be reduced. (FIG. 7)

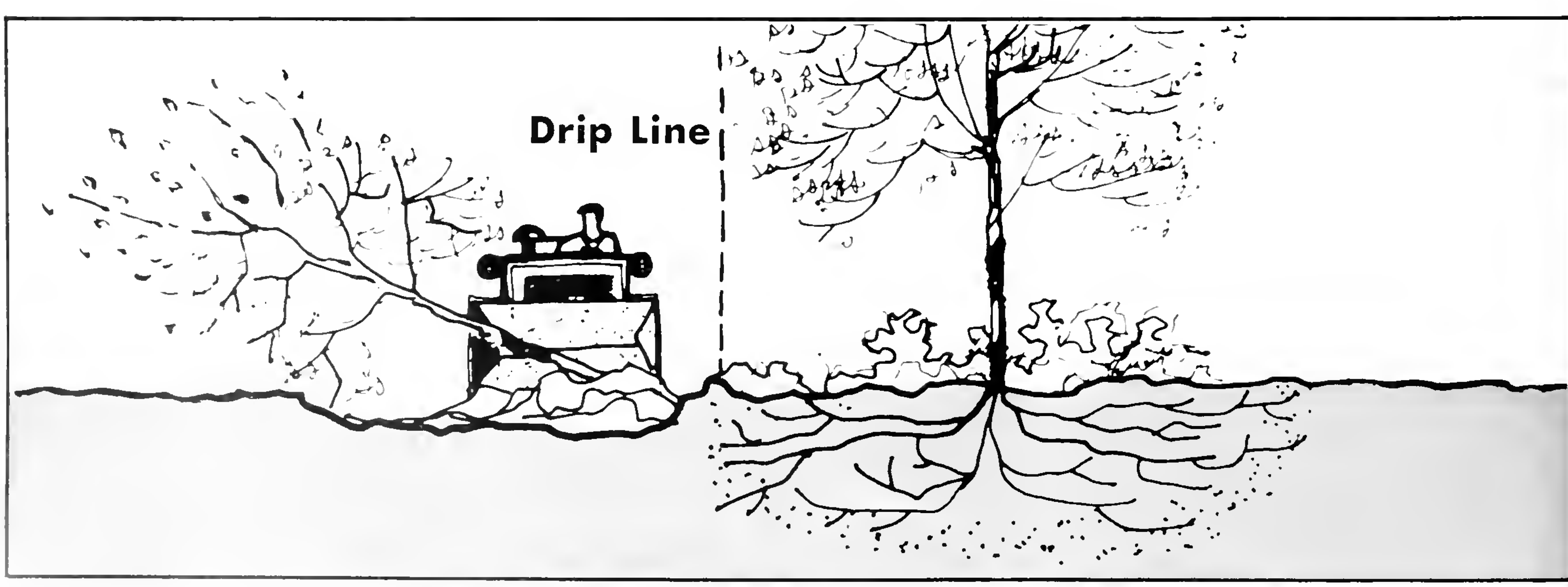


Fig. 8 — Selective Clearing

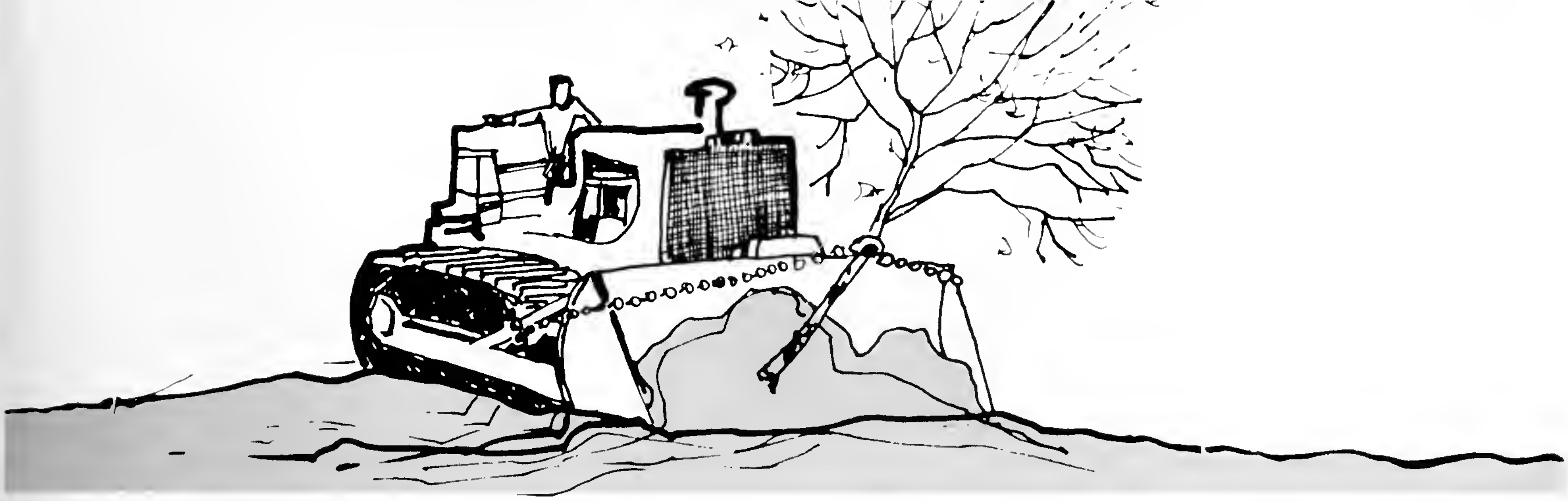


Fig. 9 — Transplanting

Proposals

Vegetation should be saved along the site periphery, on "no dig" areas or over marginal portions of the deposit if such plant preservation will appreciably enhance development plans. Vegetation is valuable for screening absorbing noise and dust, as well as an amenity around which future development can mold itself. The conservation of mature vegetation provides immediate screening without an 8 to 10 year wait as is often the case with newly planted stock.

Equipment Utilization:

Selective clearing

The bulldozer has the capacity to achieve maximum pushing and digging power without a running start which makes it excellent for selective clearing. This permits the dozer to remove trees in close proximity to plants that are flagged to remain without unnecessary jockeying around and damage to these trees by bumping, bruising or tearing of bark. Dozer clearing operations should be kept outside the dripline of trees flagged for conservation to avoid damaging their root systems. (FIG. 8)

Transplanting

Within the execution of clearing operations, conservation can be practiced by utilizing the potential of dozers and loaders with front buckets to scoop up small trees that are within the clearing area and transport them to the periphery of the site or to other conservation areas where they can be transplanted to create new screening, maintain soil stability in drainage swales, or bolster existing screens. (FIG. 9) Since these plants are indigenous to the site and clearing is normally carried out in the spring or fall, which is the dormant season for plants, this practice can have a high survival ratio.

The dozer or loader can roll or carry large boulders to the site periphery where they may be used as part of an interesting screen or as a check dam across swales to contain mudflows in the development. (FIG. 10) Boulders also provide landscape construction materials for future use.

Improved Operations

Clearing should be limited to the area equivalent to one year's excavation. The portion of vegetation remaining uncleared helps to bind the soil, dissipate the force of rainfall, and absorb moisture, which total up to a reduction in erosion and a gradual transition in environmental change. Uncleared areas of vegetation may also provide immediate and effective temporary screening, allowing time for new replacement planting on the site periphery to mature before the remaining trees and shrubs on the site are removed.

Where sites are small or for some other reason the producer clears the entire site at once, which is a dramatic change visually and micro-climatically on sites which were heavily wooded, some type of cover crop should be planted to cushion the impact of clearing operations on surrounding vegetation and reduce dust problems. A cover crop will not impede successive excavation operations because the plant growth can be peeled away with the topsoil by stripping equipment. As an additional interim benefit, on rural sites, this planting practice creates food and nesting habitat for wildlife.

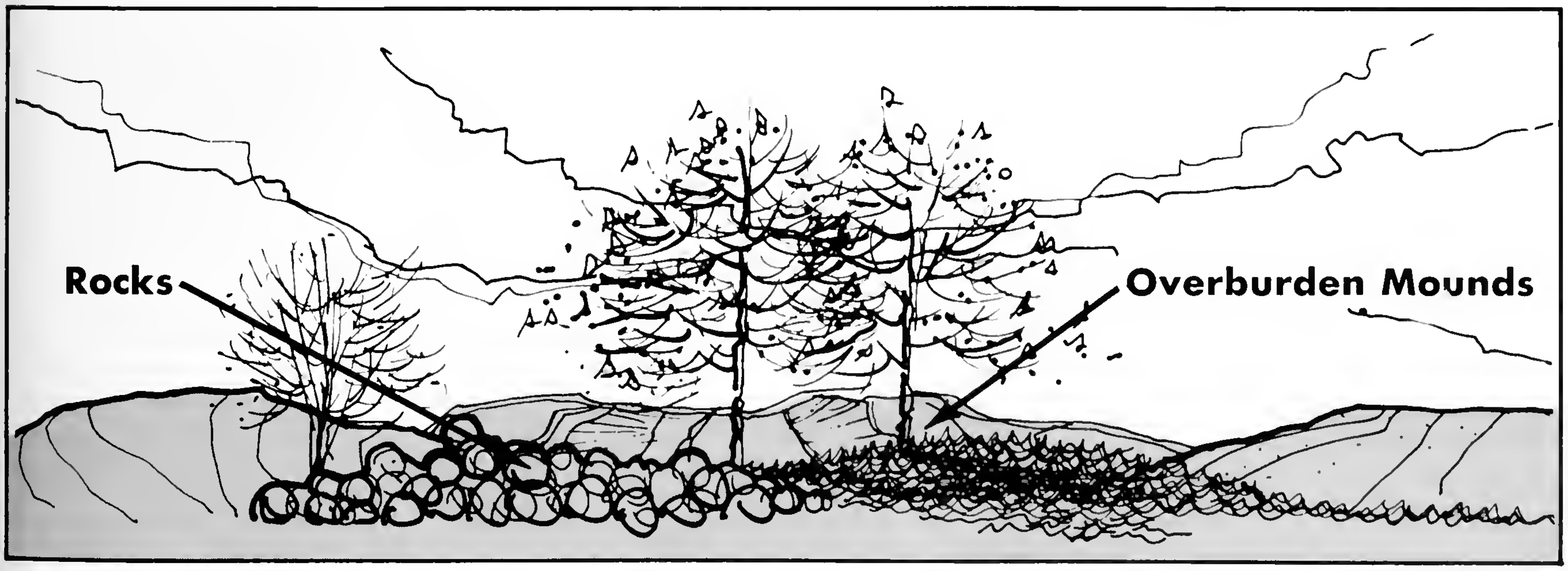
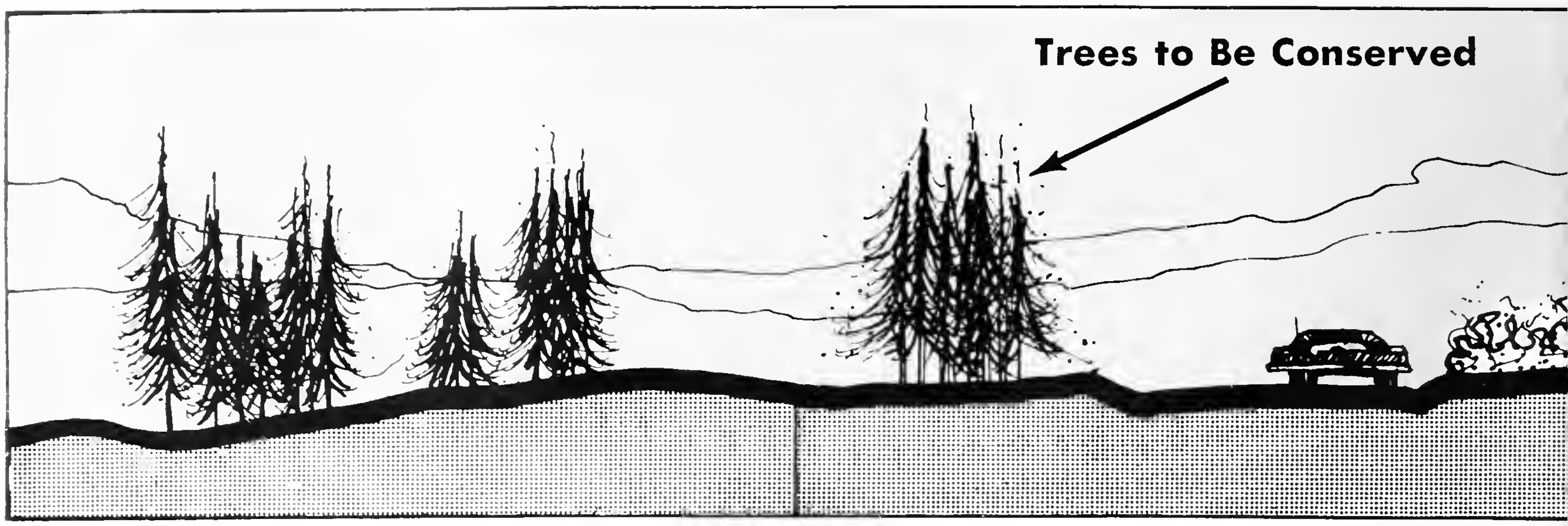
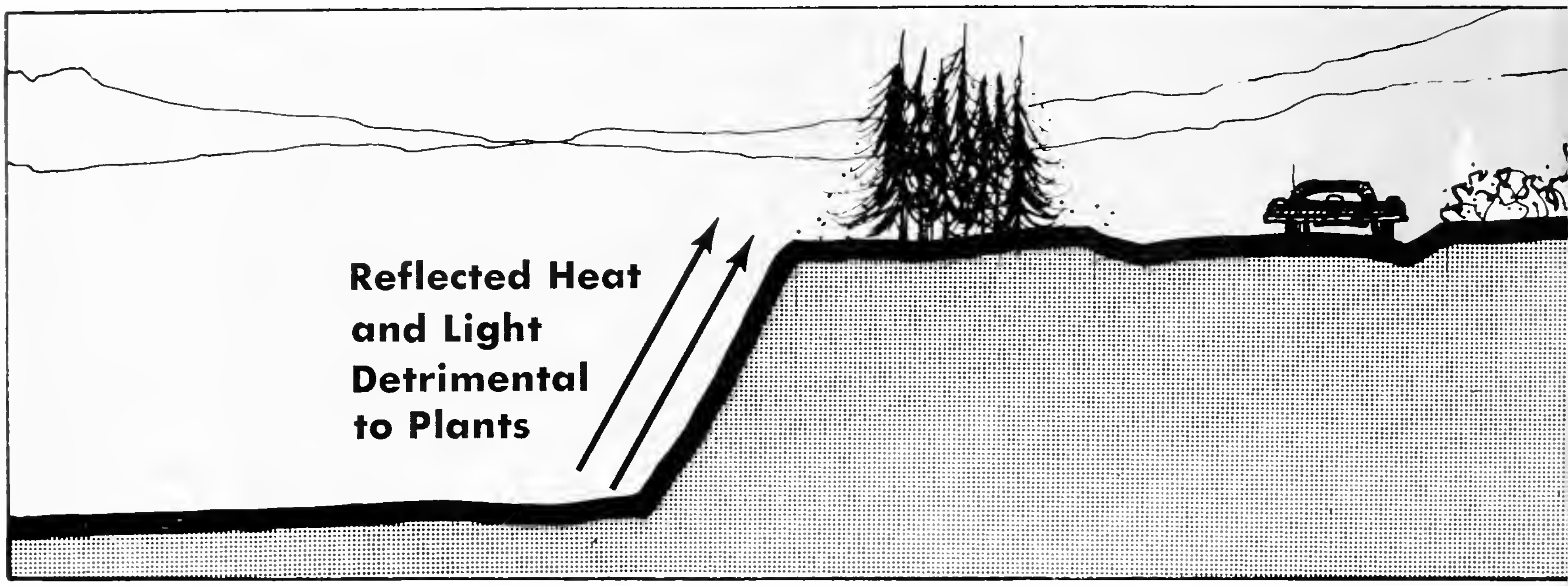


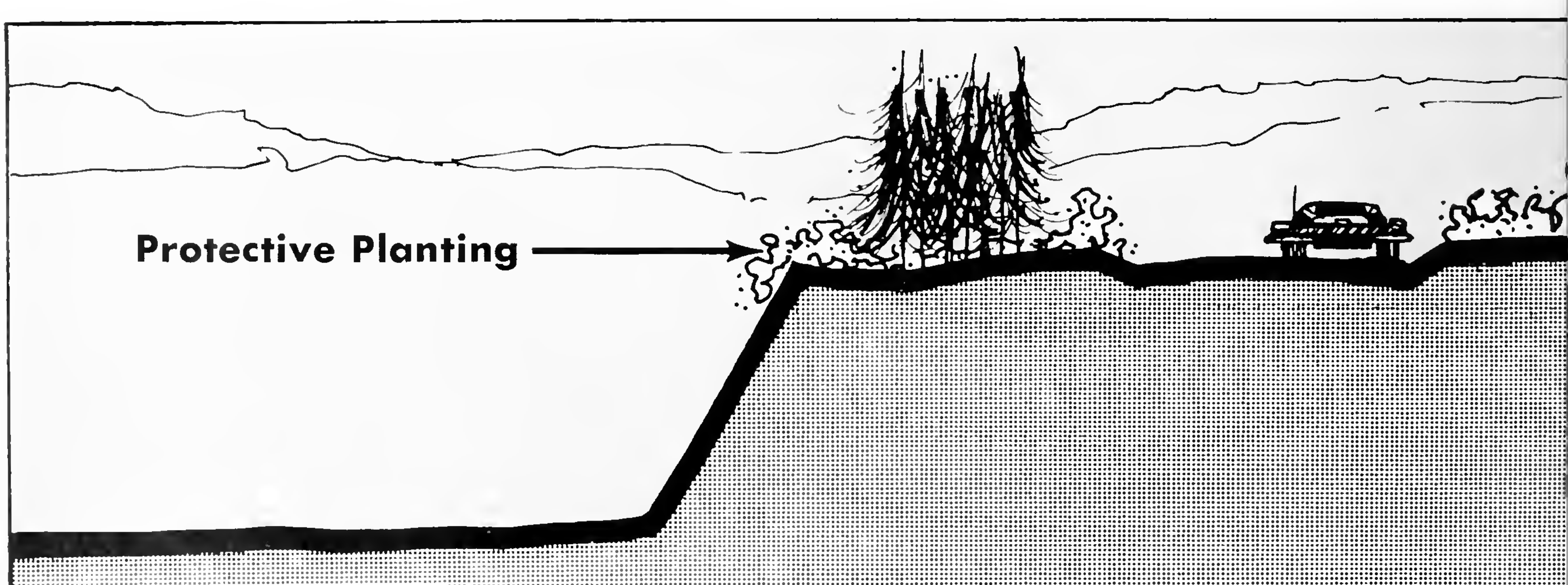
Fig. 10 — Boulders for Screening



Step 1—Existing Site



Step 2—After Excavation



Step 3—Protective Planting

Fig. 11 — Protective Planting

Planting and Conservation

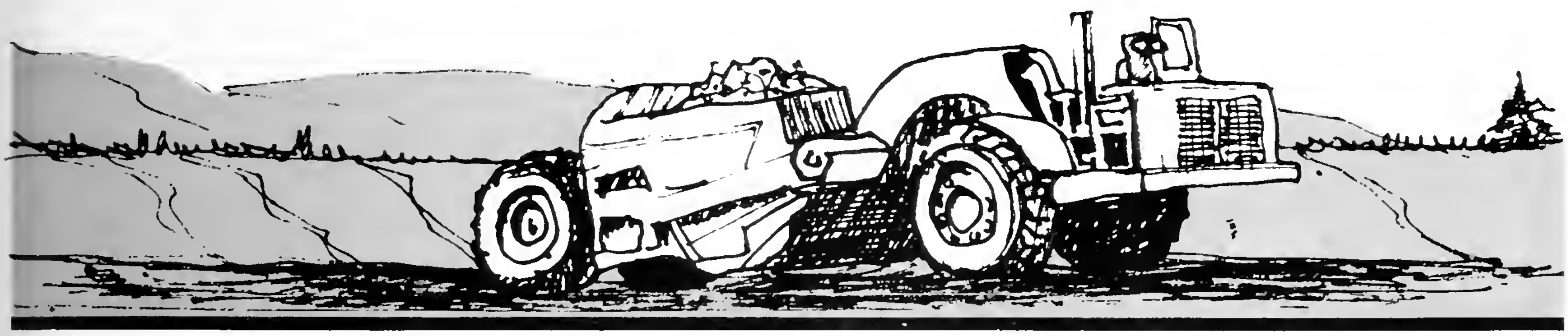
Screen planting should include the previously-mentioned conservation areas and also around the processing plant area. Hardy varieties of trees should be selected, tolerant of heat, dust and soil compaction, to insure a good survival ratio. (FIG. 11) It may also be suggested that some hardy species be planted as a buffer to protect existing conserved vegetation. Information on screen planting is available in the NSGA publication "Site Utilization and Rehabilitation Practices".

If additional screen planting is necessary to supplement conserved vegetation or to form the initial screen, it may prove beneficial to plant the nursery stock well in advance of excavation operations. This would allow the plants sufficient time to become adapted to site conditions and develop to become efficient for screening.

It is recommended that some form of useful disposal for the wood from clearing be found other than burning or wastefully destroying. Small saw mills, lumber yards, nurseries, park districts, and surrounding farmers or home owners are often willing to buy and haul away the logs and put them to constructive use.

Summary of Proposals

1. Use of the Bulldozer
   - A. Selective Clearing
   - B. Transplanting
2. Improved operation
   - A. Elimination of Waste
   - B. Screen Planting



Section 3: STRIPPING, STOCKPILING, EXCAVATION

Description

The three extractive operations of stripping, stockpiling and excavation are performed simultaneously. Stripping operations remove the various horizons of topsoil and subsoil that cover most sand and gravel deposits. The purpose of stripping is to expose the sand and gravel bearing strata and make it directly accessible to excavation and the operations that follow. Stockpiling is the storage of stripped overburden material away from the path of excavation operations, usually in set back areas, atop marginal portions of the deposit or in areas off the site. Scrapers and draglines are the most commonly used items for stripping. Dozers, loaders, and shovels are used to a lesser extent. Excavation operations unearth the sand and gravel and convey it directly to the processing plant or deposit it in stockpiles for later transportation and processing.

There are two types of excavation operations depending upon the relationship of the deposit to the water table. Wet operations are those in which excavation goes below the water table. Dry operations excavate above the water table and are usually associated with deposits such as kames, eskers and valley terrains. Some operations are a combination of these two types. For instance, dry operating procedures may be used until the water table is encountered and then the operation converts to wet excavation procedures.

Regardless of the type of excavation, most sand and gravel operations have a definite pattern of stripping, stockpiling and excavation that is characteristic for the type of equipment used to perform these operations. Typical operation patterns include fan shapes, radiating forms, and lineal shapes. (See appendix for equipment, pattern, relationship.) Patterns become erratic if large areas of unminable deposit are present and must be circumvented by the excavation equipment. Draglines, shovels, clamshells, scrapers, slackline cables and dredges are common types of equipment used for excavation. For excavation operations below the water table, dredges, draglines, clamshells and slackline cables are commonly used.

Operation Results

The visual and physical results of extractive operations on any given site will depend on a group of variable site and operational conditions which would include the type of deposit, deposit depth and composition, amount of overburden, the character of surrounding topography, operation pattern and the type or types of equipment used to perform the operation. Generally it can be assumed that extractive operations will alter the existing topography and shape it into some new form. Common alterations of topography would include (1) steep pit or hillside slopes, (2) various pit or hillside basegrade forms such as level, terraced, sloping, gently undulating, extremely rolling, corrugated, or erratic, (3) new water areas. A site may contain all, one or a combination of these land forms (FIG.12)

Slopes:

Excavation of both pit and hillside sites, in wet or dry operations, by any and all types of equipment will often create a steep slope cut of one form or another somewhere on the site.

Fig. 12 — Land Form Characteristics of Excavation Operations

(FIG. 13) The slopes will vary in height from a few feet to 300 or more depending upon the depth of excavation. One operation in the Los Angeles area is excavating at a depth of 250 feet and creating a slope around the pit of 275 feet at a gradient of 1:1. The average slope length on most sites is about 30 feet. The slope gradient will vary from near vertical to 3:1 depending on the natural angle of repose for a given deposit and/or the excavating characteristics of the equipment. Some operations that are mining under rigid zoning controls are required by law to leave the slope at a specified gradient which is generally 2:1 or 3:1.

If excavated slopes are left barren (not covered with overburden and seeded with a cover crop) or are not progressively developed during the course of operation, they will usually remain barren, and eroded, because the low nutrient level of sand and gravel is unable to support most forms of plant life which could naturally revegetate the area. (FIG. 14) With no plant growth to stabilize the slope, erosion problems are an ever present threat. Surface runoff gradually washes away portions of the slope, creating gullies which are susceptible to cave-ins. These gullies may become a hazard to surrounding development and to children playing in the depleted site. Eroding slopes may also discourage those interested in developing the site for other land uses because they are unsightly, hazardous, and would be costly to redevelop into a stable form.

Pit and Hillside Basegrade:

Excavation determines the topography of the depleted site. The topography is controlled by the characteristics of the underlying strata which contain the sand and gravel because most operations excavate a deposit to its natural depth limits. If the base of the deposit is relatively level and veins of unminable material are small enough to be removed, the basegrade after excavation will be level or gently undulating. (FIG. 15) If the site has a variable depth of deposit or large veins of unminable material that must be circumvented during excavation, the resulting basegrade will be irregular. (FIG. 16) A few urbanized areas, Los Angeles for example, have adapted zoning controls which specify the maximum depth at which excavation can occur in an effort to protect underground water reserves. The result from excavation, under these circumstances, is a level basegrade at the required maximum depth.

The basegrade character created by excavation will be altered if overburden is stockpiled in the excavated area. The size and form of stockpiled material is a product of two factors. First, the amount of overburden that is removed and stockpiled and second, the type of equipment used for stripping and stockpiling. Overburden depths vary from a few inches to sixty feet with five to ten feet considered average. Obviously, sites or portions of sites with extensive quantities of overburden will have the largest stockpiles and drastically affect the character of the basegrade. The amount of topographic change decreases with reduced amounts of overburden.

The type of equipment used for stripping and stockpiling operations (usually scrapers or draglines) will determine the form of the stockpiles regardless of the quantity of overburden involved. Scrapers frequently form stockpiles that are large and brow-shaped. (FIG. 17) This form can be easily cut down and redistributed by scrapers or dozers for rehabilitation purposes. In a few cases the producer has wisely used his scrapers to spread overburden in an even mantle over excavated areas immediately after it has been stripped.

The results of dragline stripping, stockpiling, and excavating operations create windrows of conical piles occurring at rhythmic intervals. On sites with large quantities of overburden, stockpile forms may become high and peaked with large bases. (FIG. 18) These forms become difficult to regrade for use in rehabilitation because there is no efficient or rapid way for dozers or other types of equipment to manipulate them into usable land areas. Consequently, some sites with windrows of overburden have been left in a lumpy scrubboard pattern because they were too large and cumbersome to be regraded. A site left in this condition is suitable for only a very limited number of land uses, because of the irregular grade and the fact that the site is dissected into many small segments. One of the major objectives of rehabilitation is to create stockpile forms that can be regraded economically to accommodate a number of potential land uses. The effects of dragline stripping and stockpiling operations on wet sites are discussed below in the 'Water Areas' section.

The base of many pit sites become catchbasins for surface water from the surrounding land. The water may percolate through the pit floor rapidly if the base of the pit is porous, but if the base is impervious, the water may remain as a series of shallow ponds in low areas until it evaporates. The problem with many of these water areas is that they are too shallow and periodic in occurrence to be usable and they exclude valuable land surface from use or development.

Water Areas:

Excavation on wet sites may create water bodies that vary in depth to sixty feet or more, depending upon several factors:

Fig. 13 — Steep Slope Created by Excavation

Fig. 14 — Eroded Slopes

Fig. 15 — Level Base Grade Forms

Fig. 16 — Irregular Base Grade Forms

Fig. 17 — Scraper Formed Stockpile Mound

(1) depth of the material below the water level, (2) the type of equipment used for excavation, (3) the presence or absence of unminable material and, (4) the fluctuation of the water table.

As a rule, the depth of water created by excavation is similar to the depth of the deposit, but may be slightly shallower because of material spillage during the excavation operations. There are two exceptions to this rule: First, the deposit depths may extend beyond the reach of excavation equipment, in which case, the lake bottom is generally level and the depth is established by the maximum depth the equipment can reach. Second, the operations that return overburden, waste sand or fines to the excavated area will decrease the water's depth and may in some cases fill the entire water area if the quantity of waste sand, fines, curd or overburden material is sufficient.

Water bodies can be divided into two generalized groups according to their physical characteristics. The first group would include water areas that are deep, with steep shore lines below water level and large open water areas free of land remnants, (except for occasional outcroppings of unminable material). (FIG. 19 & FIG. 20) This type of lake is typical of sites where scrapers have stripped the overburden prior to excavation by other equipment such as dredges, draglines, clamshells and cable excavators; or where draglines or other types of boom excavators are operating in shallow overburden and the return of overburden to the excavated area does not affect water depth; or where the return of waste sand or fines into the water is minimal and the lake is large enough to absorb quantities of this material without filling up. The second group of water areas is typically shallow, with windrows of material above water level, where the water is often stagnant because it cannot circulate around or through the windrows. (FIG. 21) & (FIG. 22) This type of lake is commonly the result of operations which return large quantities of overburden back into the water, which is typical of dragline operations. It may also result from shallow deposit depths below the water table or from a large return of waste sand and/or fines into the water area.

Summary:

All the discussion areas above, including slopes, pit and hillside basegrades, and water areas are generalized statements about the results of extractive operations that may arise from certain site operations and equipment characteristics, but they do not hold true in every case. A site may contain one or more of these results. The point is to illustrate that: there is a relationship between deposit, excavation equipment, operations and the final excavated form. It is advisable to study these relationships before any rehabilitation proposals are made to determine what type of results can be expected and what procedures are necessary to direct these results toward the realization of ultimate development objectives.

Potential

The producer excavating sand and gravel is a sculptor at a grand scale. The earth and its sand and gravel deposit are similar to rock, wood, or metal molded by the studio artist and

Fig. 18 — Typical Stockpiling and Excavating Patterns of the Dragline

Fig. 19 — Oriental Character Pervades in this Dragline Excavated Lake

Fig. 20 — A Beautiful Lake Formed by Dredge Excavation

Fig. 21 — Lost Potential: A Water Area Choked with Overburden from an Unplanned Dragline Operation

Fig. 22 — Shallow Water Area

the excavating equipment is different only in scale from the artist's hammers and chisels. For the producer and his equipment to achieve the most sculptural and functional forms for the site, two rehabilitation principles should be observed: (1) In terms of ultimate site development, maximum results can be achieved with minimum additional expenditures of funds and effort by integrating rehabilitation with excavation to meet the final site requirement and esthetic considerations. Rehabilitation during excavation will avoid expensive land alterations at the completion of the project. (2) The use of equipment and operations for site development should be planned prior to excavation so that the potential of each is utilized efficiently.

Proposals

In this section, the use of equipment is discussed as it applies to typical operational results, slopes, basegrade, water areas, and, its use in creating some special features.

Equipment Utilization:

Screening

The objectives of screening are to block views of the objectionable portions of sand and gravel operations, frame interesting portions of the site, such as the processing plant, water areas, or rehabilitated land, and reduce noise and dust

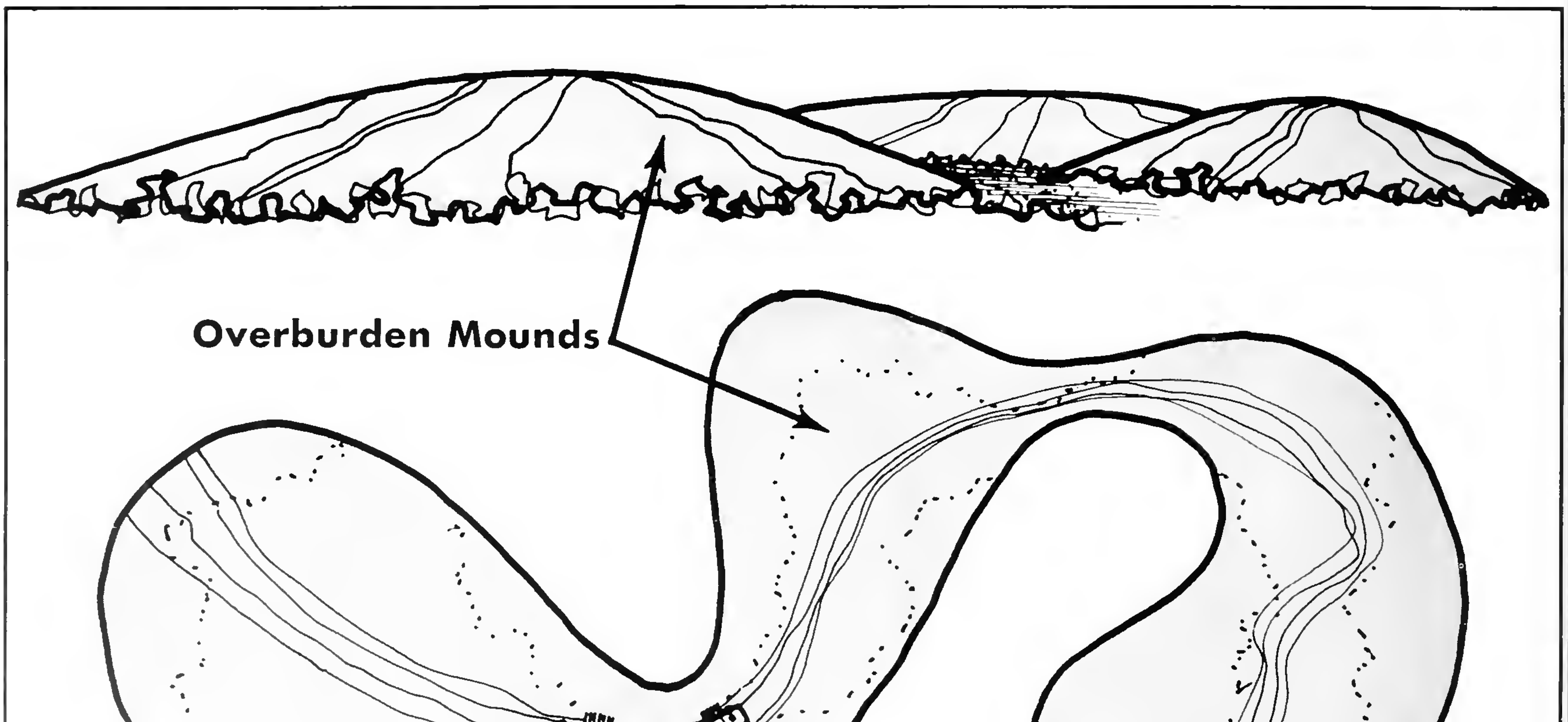


Fig. 23 — Scraper-Mound Screen

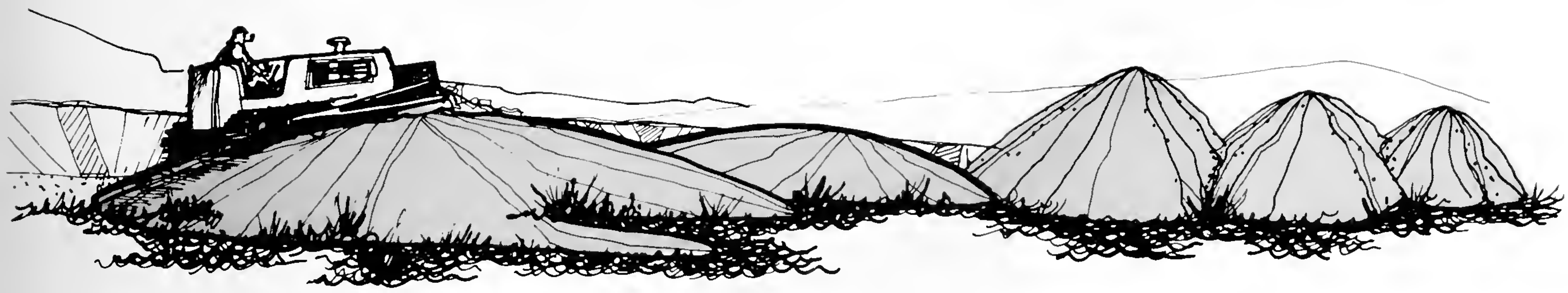


Fig. 24 — Dozer, Dragline, Mound Screen

problems. Overburden provides an immediate source for screening material since portions of it are usually stockpiled along the periphery of the site where it can be used as a buffer between operations and the surrounding land uses. Overburden can be used, as needed, for fill material after being used as a screen, unless it is desirable to maintain screening for further land uses as specified in a development plan. In such case the mound should be made a permanent land feature at the time it is placed on the site periphery.

All types of equipment used for stripping or stockpiling are capable of creating overburden mounds of one form or another. Scrapers and draglines are the two most common types of equipment used for stripping and stockpiling and thus should become directly involved in forming screening mounds. Scrapers, with their ability to deposit fill in smooth forms, are well adapted for creating interesting undulating screening mounds of varying heights. (FIG. 23) Mounds formed by draglines often look like a regimented series of mounds marching along the property line. To improve the appearance of these mounds it is recommended that a dozer be utilized to shape the mounds into pleasant forms. (FIG. 24)

Possibilities for shaping mounds into interesting forms depend upon set back requirements and the quantity of overburden, as well as equipment. In narrow set back areas, the shaping of mounds is limited to rounding the top and sloping the sides because there is not enough room to manipulate the material into artistic forms. In such cases, it may be desirable to bring mounds back into the site over marginal deposit areas and relieve the barrier-like appearance of a long thin mound form. Sites with large set back requirements offer ample space to create interesting screening compositions. Slopes on all mounds should be constructed so that they can be mowed to control weeds and/or maintain a cover crop. A 3:1 slope is maximum machine mowable grade. Cover crops should be planted too, on the mounds, to stabilize slopes, help control weeds, and improve mound appearance.

There is no ideal size or shape for screening mounds. The height necessary to obstruct objectionable views depends upon the height of the observer and the distance between the observer and the object. A general rule is to construct mounds that will completely screen objectionable views. Those which hide only a portion of the objectionable features of a sand and gravel operation will only increase the viewer's curiosity to see what is behind the rest of the mound. A mound along and close to a road, for example, should not become too large or overpowering, because it may create a visual image as objectionable as that which it is trying to screen. In some cases, screen planting can be used to accent the mounds or expand the possibility of screening views on or off the site.

It may be desirable to make some quick elevation sketches relating the observer's eye level (five feet, six inches for a man standing, and four feet, seated in a car) to the mound from various points to insure that objectionable views are screened and that the mound forms are desirable and in scale with the surroundings. (FIG. 25)

Slope Development

The objectives of slope development for pit walls or hillsides is to create slopes that are stable (will not erode) and, if possible, slopes that are usable parts of the site. There are three basic approaches to slope development: (1) Controlled use of excavation equipment to create gradual slopes or terraces and to cover them with overburden during the course of the excavation operation (applicable to sites with small quantities of overburden). (2) Use of overburden to fill out the slope, following closely behind excavation operations, (applicable to sites with large quantities of overburden). (3) Use excavation equipment to round off the slopes from above or to cut them back from above and cover them with overburden after excavation.

Approach 1

In most operations the pit wall can be sloped to a desired percentage during the excavation operation. This requires that

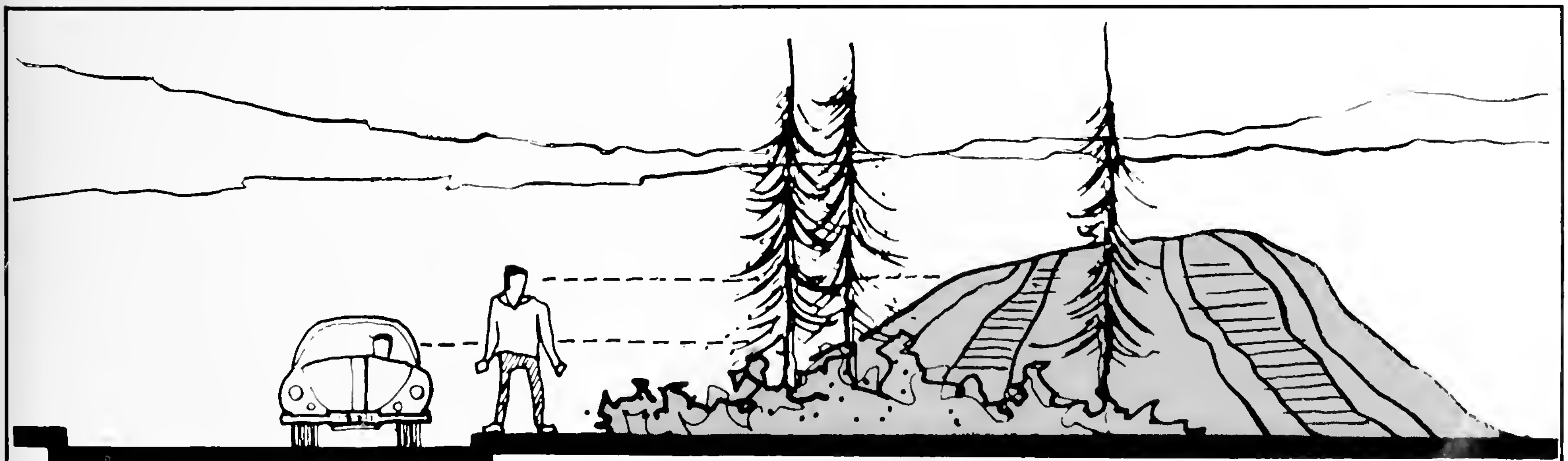


Fig. 25 — Elevation—Mound Screen

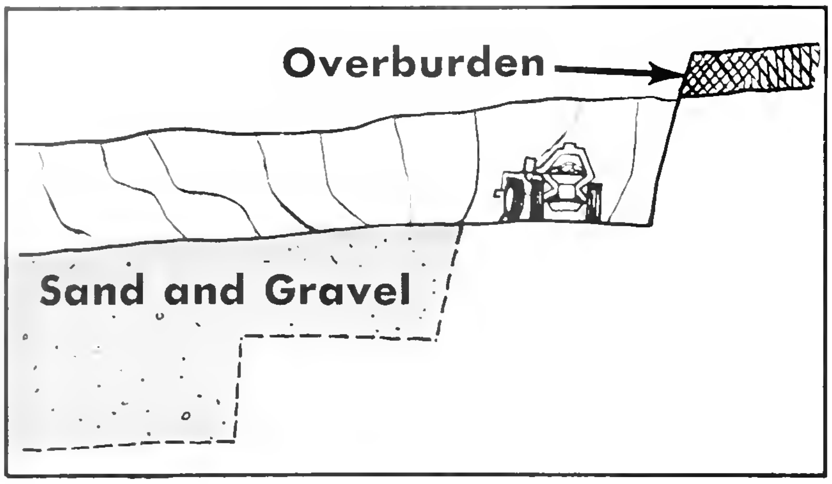


Fig. 26 — Scraper—Terracing

the specified slope gradient be adopted prior to excavation. Sand and gravel will not be mined behind the designated toe of the slope. To create the desired slope, excavation equipment should proceed along the cut line at the specified percent of gradient from the top of the slope to the pit floor. Once the desired slope is created, overburden can be pushed down the slope or built up from below. It should be noted that the percent of the deposit left untouched increases with a decrease in the slope grade; slopes should be kept to a 2:1 or 3:1 range to minimize deposit waste unless development-returns, in the form of increased land value from buildable sites, from a lesser gradient, make such slopes feasible.

Terracing is a form of controlled excavation. The idea behind terracing of pit walls or hillsides is to work the slope in a series of benches. Terraces serve several functions: They break the erosive force of surface water which will reduce erosion; they catch debris falling from above, that may cause damage or injury to development or people below. They also provide shelves for planting and for buildings, roads, warehouses, trail systems, etc.

The horizontal width of the terrace will depend upon the gradient of the slope, the type of excavation equipment, its digging reach, and the physical requirements for a land use, if any are proposed. Generally the terrace widths should allow space for the excavation equipment to maneuver. Scrapers will require turning space; the boom type excavators will need rotating room for casting overburden and loading trucks. In some cases, room for transportation equipment will need to be provided on the terrace. It is recommended that the terrace width be kept to a minimum unless large widths are required for a specific land use where losses in unmined material are justified by increased land values. The terrace should be pitched back toward the slope to drain water into the cut. This forms a diversion ditch for water which can be collected at various points along the bank and drained down grassed or paved waterways to collection areas at the bottom of the pit.

Terracing by scrapers is a process of excavating a continuous series of gradually descending benches. The scraper operations should be organized so that the overburden, covering the first terrace, is stripped and transported to the site periphery, where a screening mound can be developed. Once the first terrace is formed, overburden covering the second terrace should be stripped and deposited on the first terrace while the second terrace is being excavated, etc., until the pit floor or basegrade of the hillside is reached. (FIG. 26)

Shovels, clamshells, or draglines can be used to create terraces if excavation along the pit wall or hillside is organized into a series of gradually descending benches. If these types of equipment are used for stripping and stockpiling as well as excavating, it is recommended that the overburden be cast back onto the previously excavated terrace or the material can be loaded into trucks and dumped on the above terrace. (FIG. 27) If scrapers are used for stripping purposes, prior to excavation, it is recommended that they be used to resurface the terraces

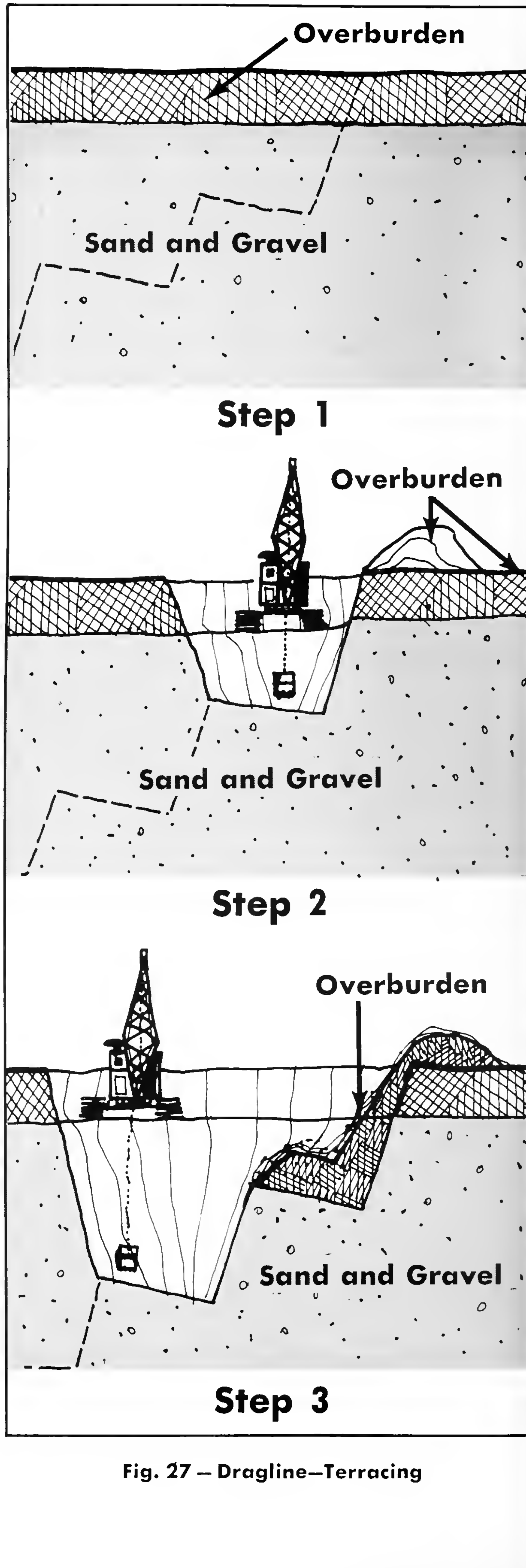


Fig. 27 — Dragline—Terracing

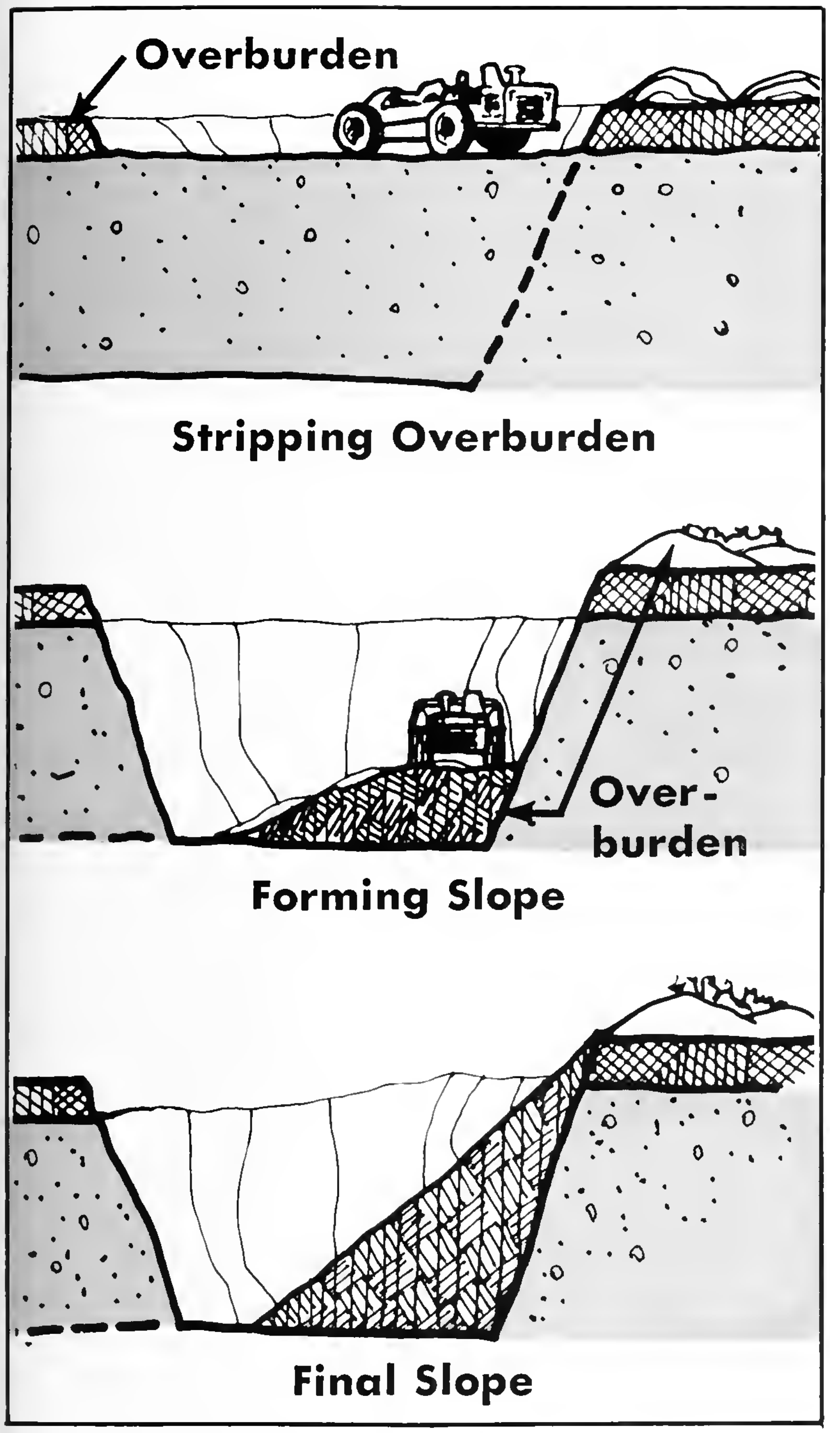


Fig. 28 — Scraper—Filling Out Slope

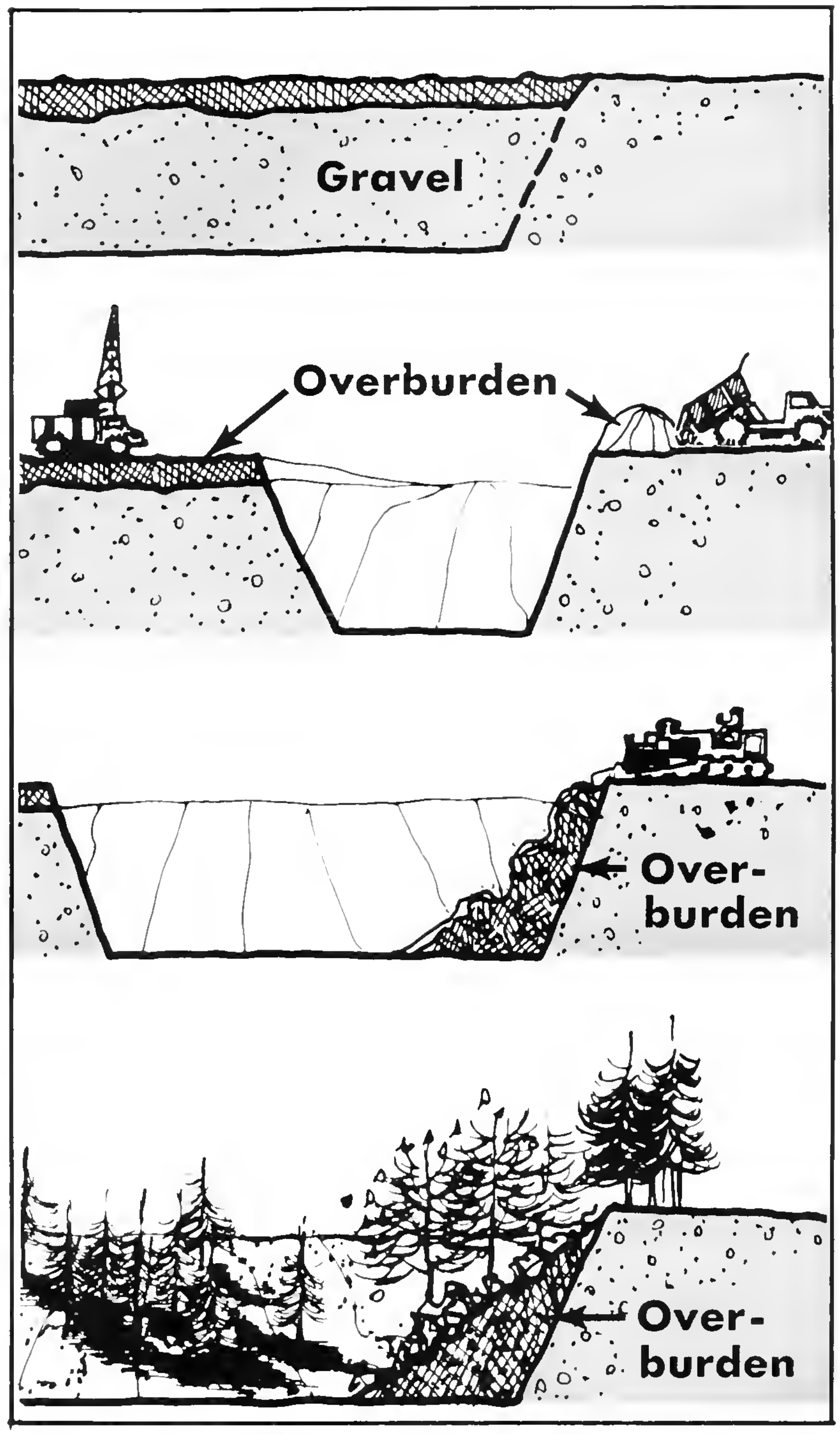


Fig. 29 — Dragline-Truck-Dozer—Filling Out Slope

with the overburden. This overburden can be leveled out so the terrace may serve as a haul road or, if it is not necessary, trees, shrubs, and grasses can be planted (during slack periods in the spring or fall).

Approach 2

Sites with large quantities of overburden have an asset for slope development. Excavation can proceed as normal right up to the set back line, so that the maximum quantity of sand and gravel can be removed. This will leave a near vertical pit wall which can be filled to the desired grade with overburden. Scrapers can be used for this type of slope development by dumping the overburden removed during stripping operations on the excavated pit floor up against the pit wall and to gradually build up the slope. (FIG. 28) Trucks used in combination with boom type stripping equipment can follow a similar procedure by trucking and dumping overburden from the excavation site to the base of the pit wall. (FIG. 29) Boom excavators, particularly the dragline, can stockpile in an incline manner (tallest piles nearest the bank, becoming smaller as they move away from the bank), thus putting the largest quantity of earth up near the bank where it is needed. Bulldozers can then be used to smooth out the overburden into an even grade or more material can be dumped over the slope from above to achieve the desired gradient. (FIG. 30)

Approach 3

The simplest approach to slope development, for all types of excavating equipment, is to excavate in the normal manner, leaving a vertical working face. Then, after excavation has moved away from the pit wall, the bank can be pushed in from the top by bulldozers to create a slope which will assume the material's natural angle of repose. (FIG. 31) Overburden and topsoil can be pushed over this slope from above to form a base for plant growth. Since a slope formed in this manner is an uncompactable fill, it should be formed only where it will initially receive limited use so that it can properly settle after which it can be developed for a variety of uses.

The dragline can work from above the bank and cut a slope back toward itself. Since the operation is cutting a bank that has been naturally compacted, the slope created will be stable. The dragline remains at the top of the slope, casts its bucket to

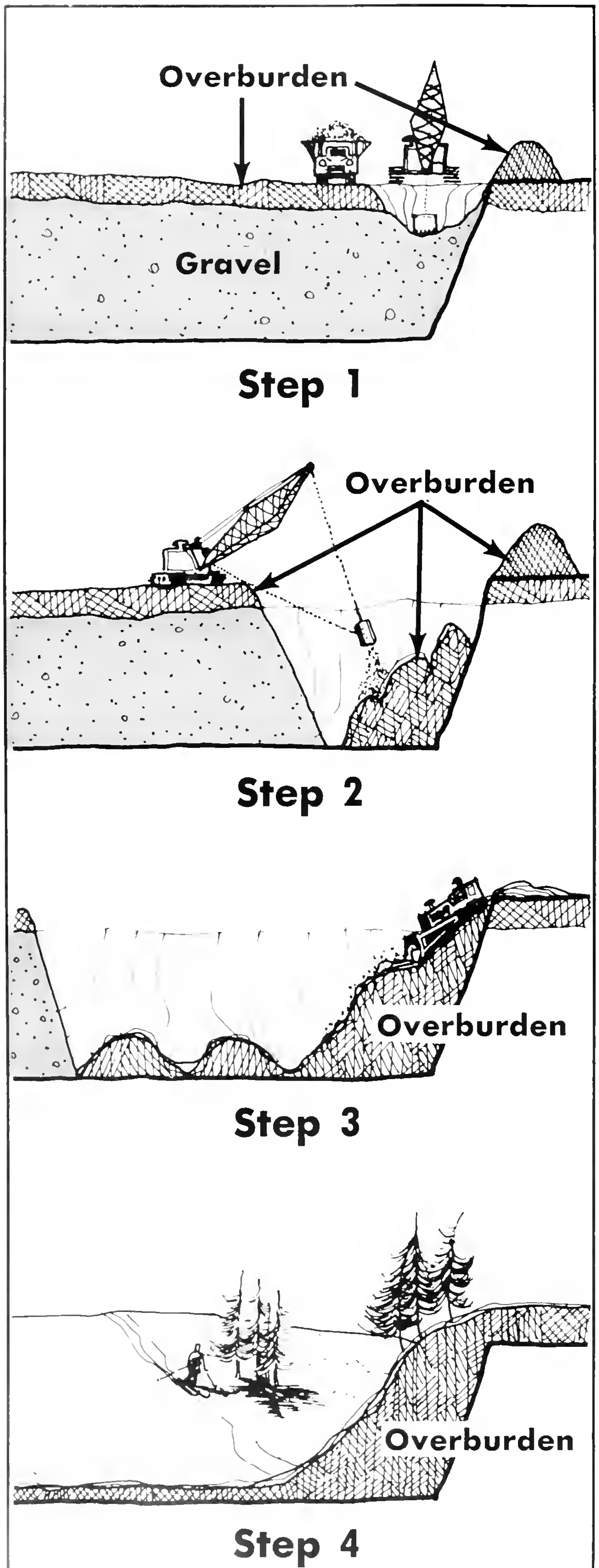


Fig. 30 — Dragline—Inclined Stockpiling

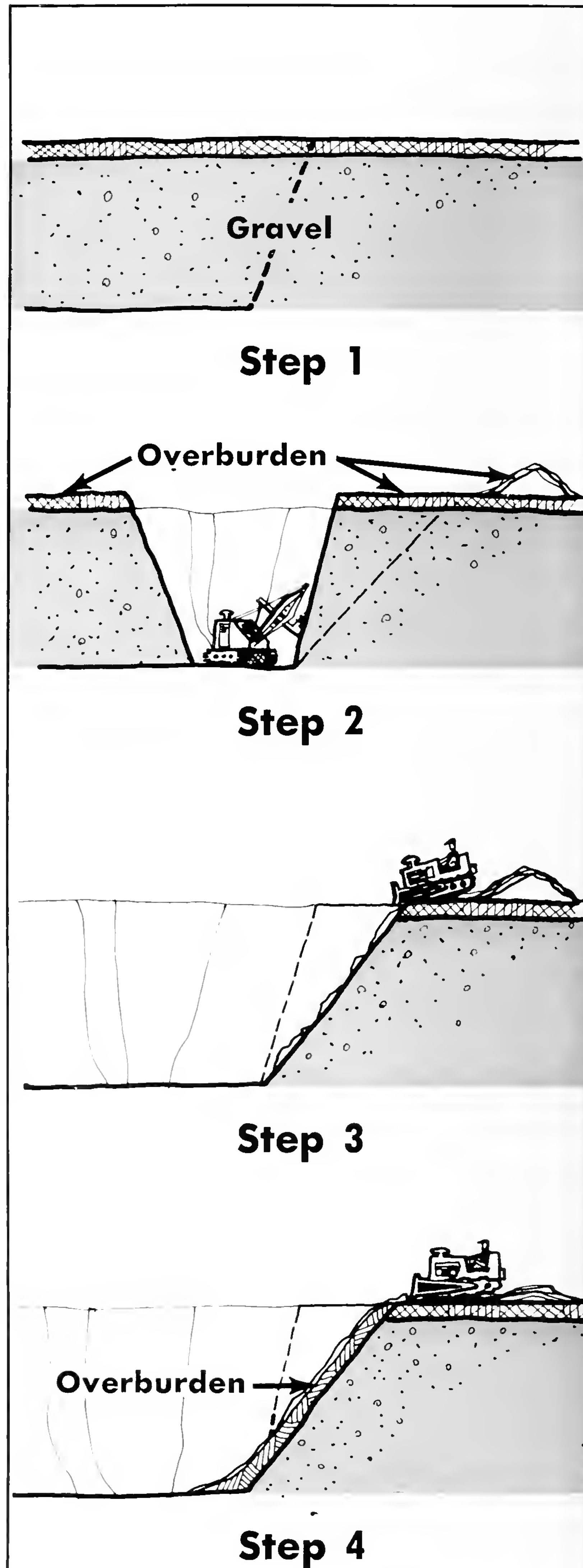


Fig. 31 — Dozer—Cutting Back Slope

the bottom, and then pulls it up through the sand and gravel, cutting a slope toward itself. Once the desired slope is achieved, the dragline can cast the overburden that is stockpiled along the site periphery down the slope. (FIG. 32) It is suggested that such slopes be formed where they will receive only limited use, at least until the bank has had time to settle properly, because the material is uncompacted and will not withstand intense use without erosion.

Basegrade Preparation

Basegrade preparation procedures (the construction of drainable and buildable topography on the bottom or hillside of a pit) consist of: Excavating to elevations specified in the grading plan, and covering the excavated area with overburden and topsoil. Basegrade preparation becomes the important rehabilitation procedure after excavation operations have worked away from the edge of the property and down to the base of the deposit. As with slope development, basegrade preparation should be continued simultaneously throughout the duration of excavation operations so that the site can be progressively rehabilitated. The objectives of a basegrade preparation plan are similar to any grading plan: To insure proper site drainage; to create an adequate foundation for land uses and other functional necessities, and to sculpturally mold the land into esthetically pleasing forms. The procedure necessary to implement a basegrade preparation program is strongly influenced by the type of excavating equipment and its operating characteristics because each type of equipment offers opportunities and limitations that must be considered.

Scrapers:

The rubber-tired scraper and the tractor-drawn scraper have the ability to strip the overburden off the deposit, excavate the sand and gravel to the planned specified depth, and redeposit overburden in the desired location, to the desired depth without the aid of other grading equipment. In essence, the normal operating procedures for these types of equipment are the same as the "Progressive Rehabilitation Cycle". (FIG. 33) All that is recommended to maintain operating efficiency, as well as achieve rehabilitation objectives, is a flow diagram which will balance long and short hauling distances for the redeposition of overburden to insure that the average hauling length remains within the efficient operating range of the equipment.

Rubber-tired and track excavators are also used for stripping and stockpiling purposes on sites where boom equipment, cable excavators and dredges are used to excavate sand and gravel. Consequently, the cycle for basegrade preparation, just discussed for scrapers, can be adapted to these operations by interjecting the type of boom, cable, or dredge excavator into the diagram at the excavation stage. The role of the boom or cable excavating equipment in a combined operation is to excavate to the prescribed depth, while the scraper resurfaces the excavated area with overburden and topsoil. Numerous illustrations throughout the text show the use of the scraper for stripping and rehabilitation purposes in conjunction with other types of excavating equipment. (FIG. 34) & (FIG. 35)

Boom Excavators:

In some cases boom types of excavating equipment—draglines, clamshells, and shovels—are not proceeded by other types of stripping machinery. Draglines, for instance, frequently perform stripping, stockpiling and excavating operations simultaneously and can be utilized for basegrade development. Draglines or other boom types of equipment used for stripping shallow overburden (3 - 5 feet deep) prior to excavation, and casting it into stockpiles in previously excavated areas, can be easily adapted to a basegrade preparation program because the stockpiles are small enough to be regraded by dozers. All that is required is a systematic plan to redistribute these small overburden stockpiles with dozers or loaders into an even mantle, completely covering areas exposed by excavation. (FIG. 36) It is recommended that the material be redistributed as soon as possible after excavation so that planting can begin.

Difficulties can arise where boom types of equipment are used for stripping extensive deposits of overburden. The solu-

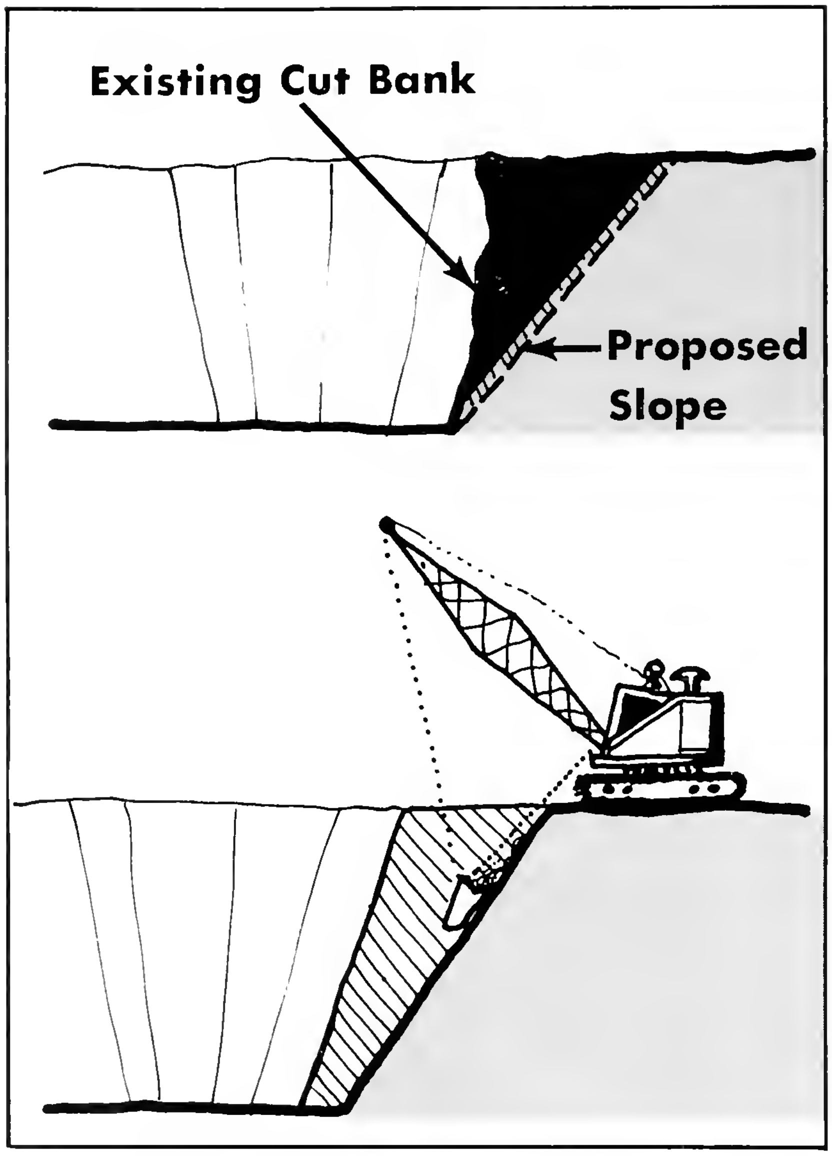


Fig. 32 — Dragline—Cutting Back Slope

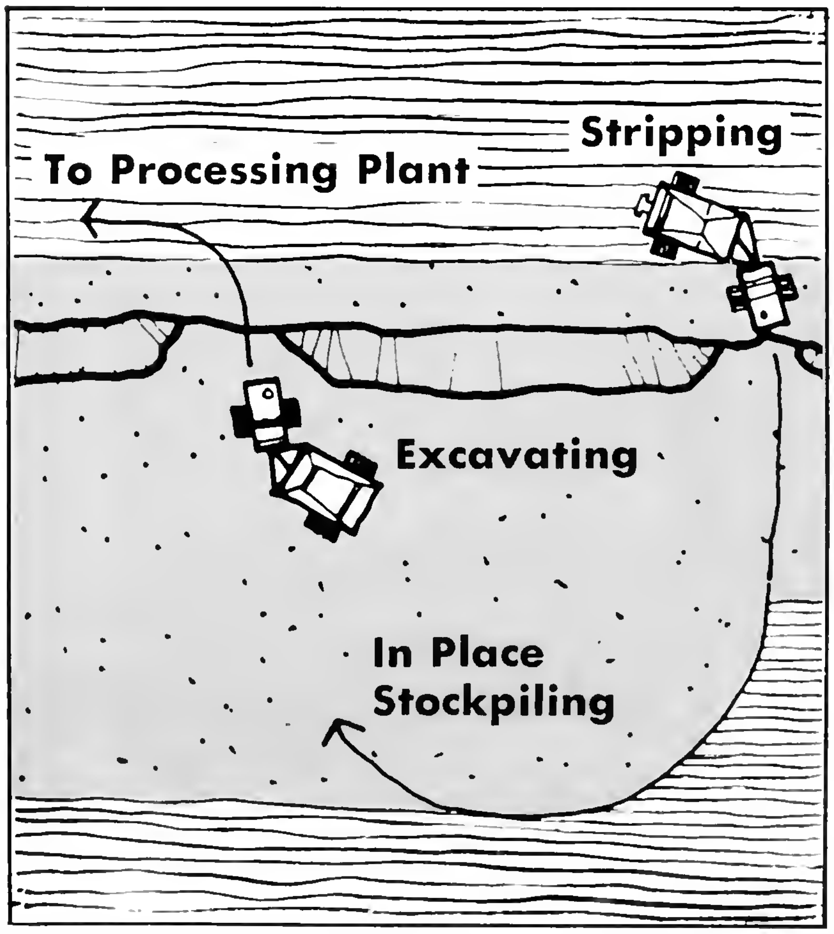


Fig. 33 — Scraper—Developing Base Grade

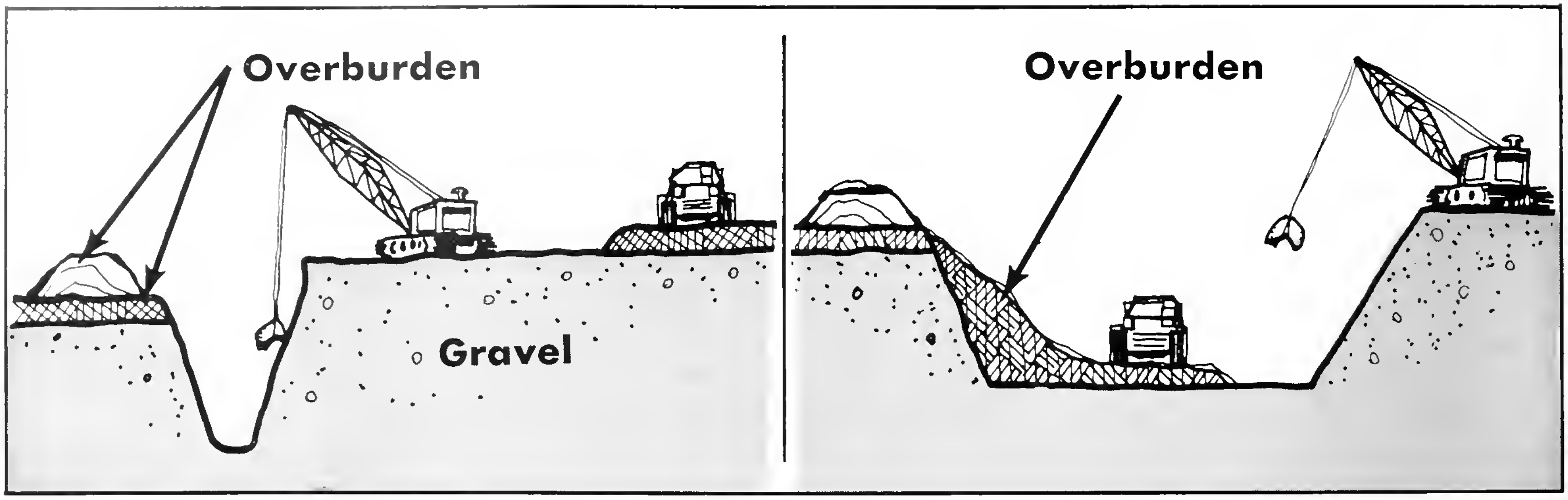


Fig. 34 — Clamshell-Scraper—Developing Base Grade

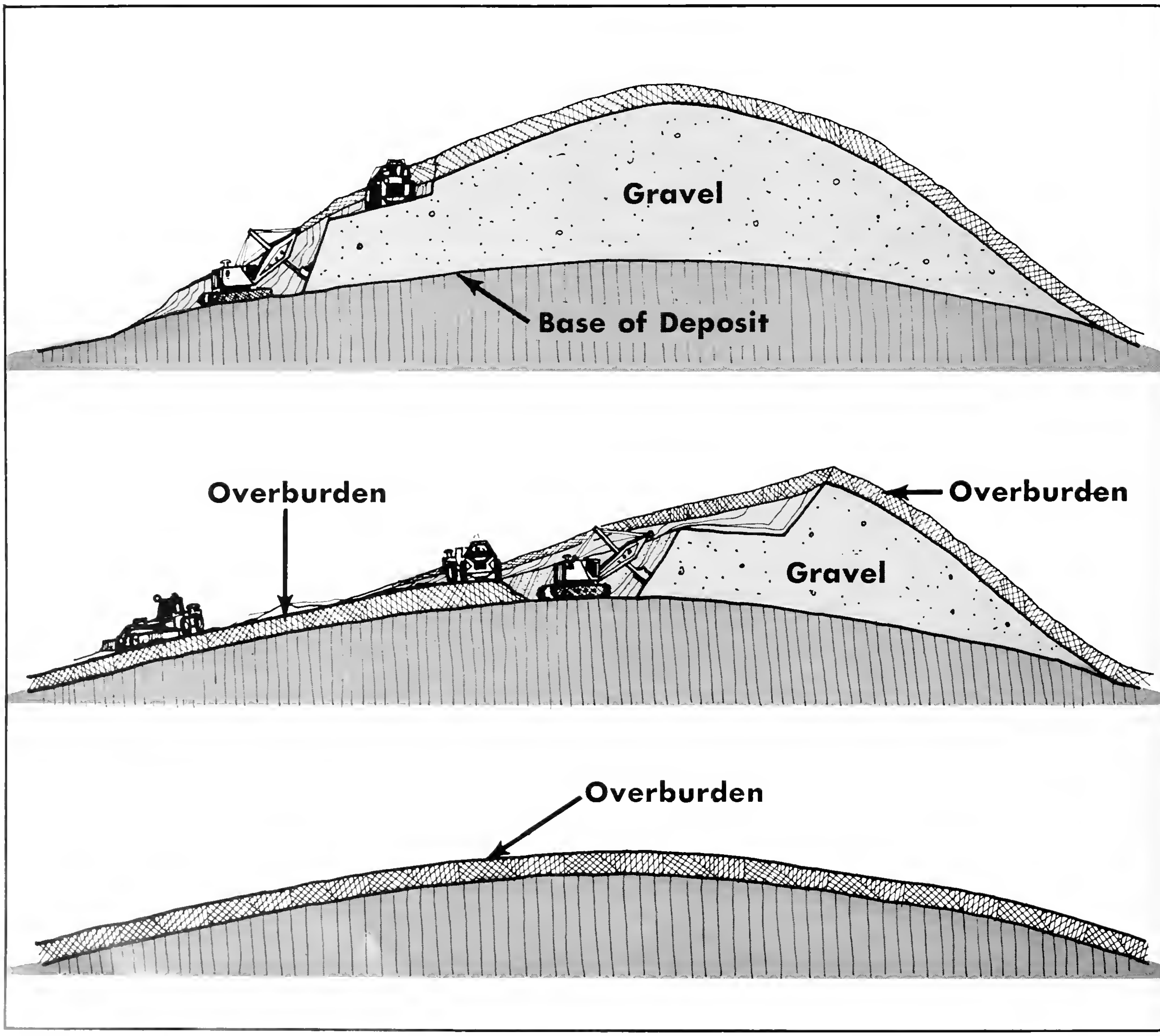


Fig. 35 — Combination of Equipment—Hillside Development

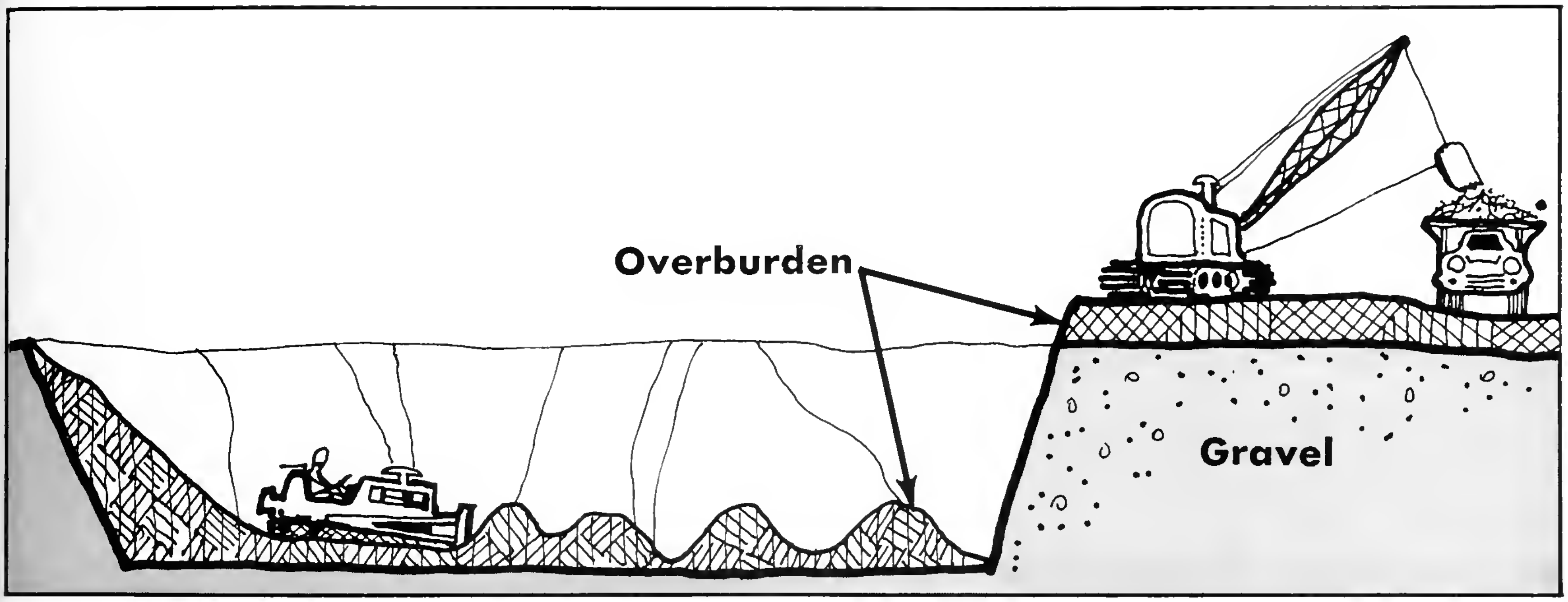


Fig. 36 — Dragline-Dozer—Base Grade Development

tion is to limit stockpile size and form to a proportion that can be economically redistributed into usable and drainable grades by dozers and scrapers. Redistributing the material is necessary to remove the undulations, often 20 feet high or more, from the characteristic scrubboard pattern of dragline operations.

Modifying the normal operating pattern by organizing an excavation program that will incorporate short frequent moves along the digging path and stockpiling the material into two small windrows is one method of keeping stockpile size to a workable proportion. The two windrows of material will, in essence, form a plateau, which dozers or even scrapers can level out and make confluent with succeeding windrows. (FIG. 37) Shortening the boom length or adapting operating patterns that reduce the space between windrows, shortens the distance necessary for regrading equipment to move the material to establish a uniform grade.

These solutions may necessitate a smaller excavation area and thus require an increased number of digging passes to extract the sand and gravel. Consequently, production cost will increase slightly, but in most cases the increase in land value, because of planned rehabilitation, will more than cover these expenses.

Utilizing trucks in combination with the excavating machinery to redistribute part of the overburden is another approach. Trucks would add the mobility feature to the operation and allow overburden to be deposited beyond the normal casting reach of boom equipment in locations where it is most beneficial to site development. A system could be organized whereby trucks remove only a portion of the material to be stockpiled, leaving an adequate amount for bulldozers to grade over the exposed sand and gravel in the immediate excavation area.

Manhandling the windrows of overburden, after excavation, is recommended only on sites where no other method is feasible. This procedure begins by leveling one of the windrows to create a platform for the excavating equipment. The equipment then works off the top of this platform along the axis of the windrow, excavating the overburden from the windrow, and depositing it in the low area between windrows, until the area is leveled. Manhandling the stockpiles is the least desirable basegrade preparation technique for several reasons: It is more expensive than the previously-mentioned techniques because it involves a second and possibly third handling of the material; it is dangerous because equipment working on top of an uncompacted windrow can easily slide off the pile; and rehabilitating after excavation fails to realize the benefits of progressive site rehabilitation. (Progressive utilization of the site by land uses and cover crop seeding and planting, as soon after excavation as possible so that vegetation can become established.)

Cable Excavators

To insure proper development of the basegrade, excavation by drag scraper or slackline cable should be controlled by a grading plan and the overburden should be replaced in previously excavated areas by the method applicable to rubber-tired or boom excavators.

Water Areas

Most uses for water areas, such as swimming, boating, fishing, manufacturing, and fish hatcheries, to mention a few, are most successful in lakes which are clear and deep. Relatively few uses, with the exception of bird sanctuaries, hunting preserves and other similar extensive uses, can utilize water areas that are shallow, stagnant and choked with overburden and weeds. Thus, on most sites, the objectives of equipment utilization for water area development are to: (1) create water areas that are free of windrows of material and deep enough to meet the demands of the proposed use and (2) develop the land surrounding the water into usable portions of the site.

Scrapers:

The scraper is often involved in wet site operations as a stripping and stockpiling tool, in advance of excavation operations by dredges, clamshells, cable excavators and, in some cases, draglines. The use of the scraper for this purpose accomplishes two objectives that are important for rehabilitation: (1) It eliminates windrows of overburden in the water, (2) and provides the possibility of using the overburden as fill material, to create peninsulas of buildable land, and (increasing the land areas) from the shoreline into the water area.

The possibilities for creating buildable land on a site depend upon the amount of overburden available for land forming, the depth of water where filling will occur, and the physical composition of the overburden used for filling. Before land development operations are undertaken, it is recommended that enough overburden be set aside to completely resurface exposed areas of sand and gravel left by excavation, as described in the 'Basegrade Development' section.

For economic development, the size of the land form should be adequate to meet the functional requirements of the proposed land use. Residential, commercial and industrial land uses have definite space requirements for buildings, parking, utilities and other services which must be satisfied if they are to be economically adaptable to the site. For example, if a peninsula land-form were to be developed for residential pur-

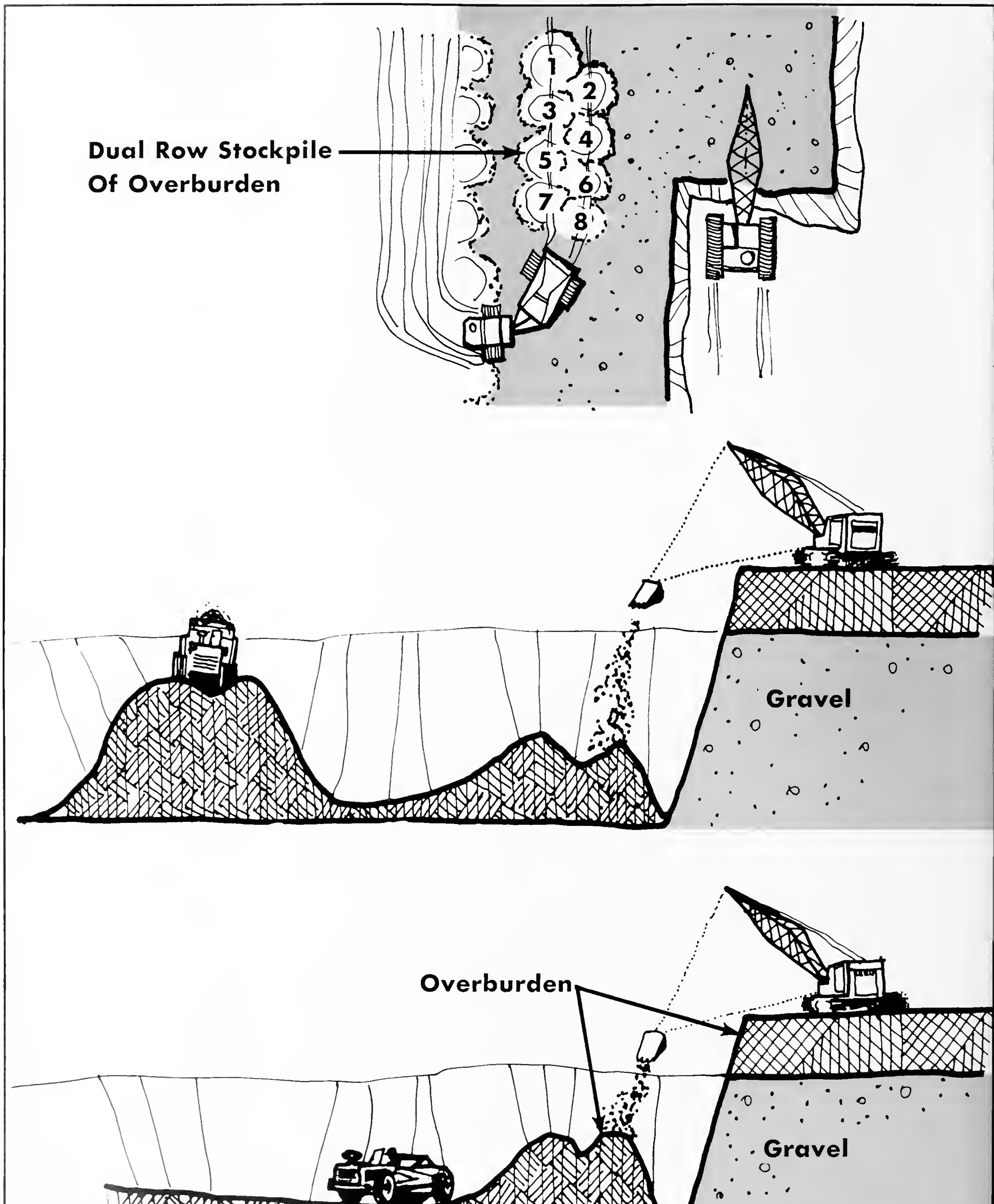


Fig. 37 — Dragline-Scraper—Dual Row Stockpiling and Base Grade Development

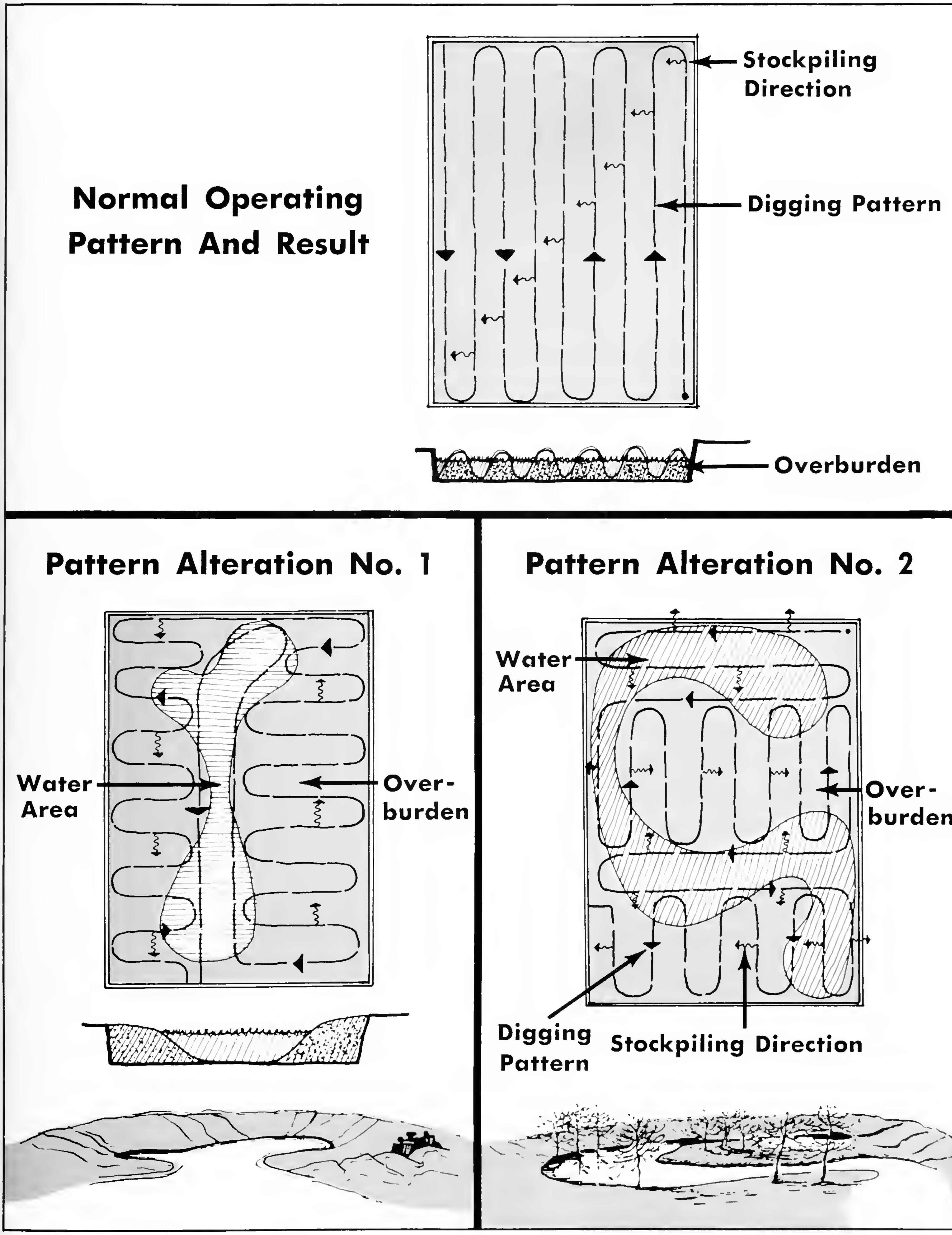


Fig. 38 & 39 — Dragline Pattern Alternation—Water Area Development

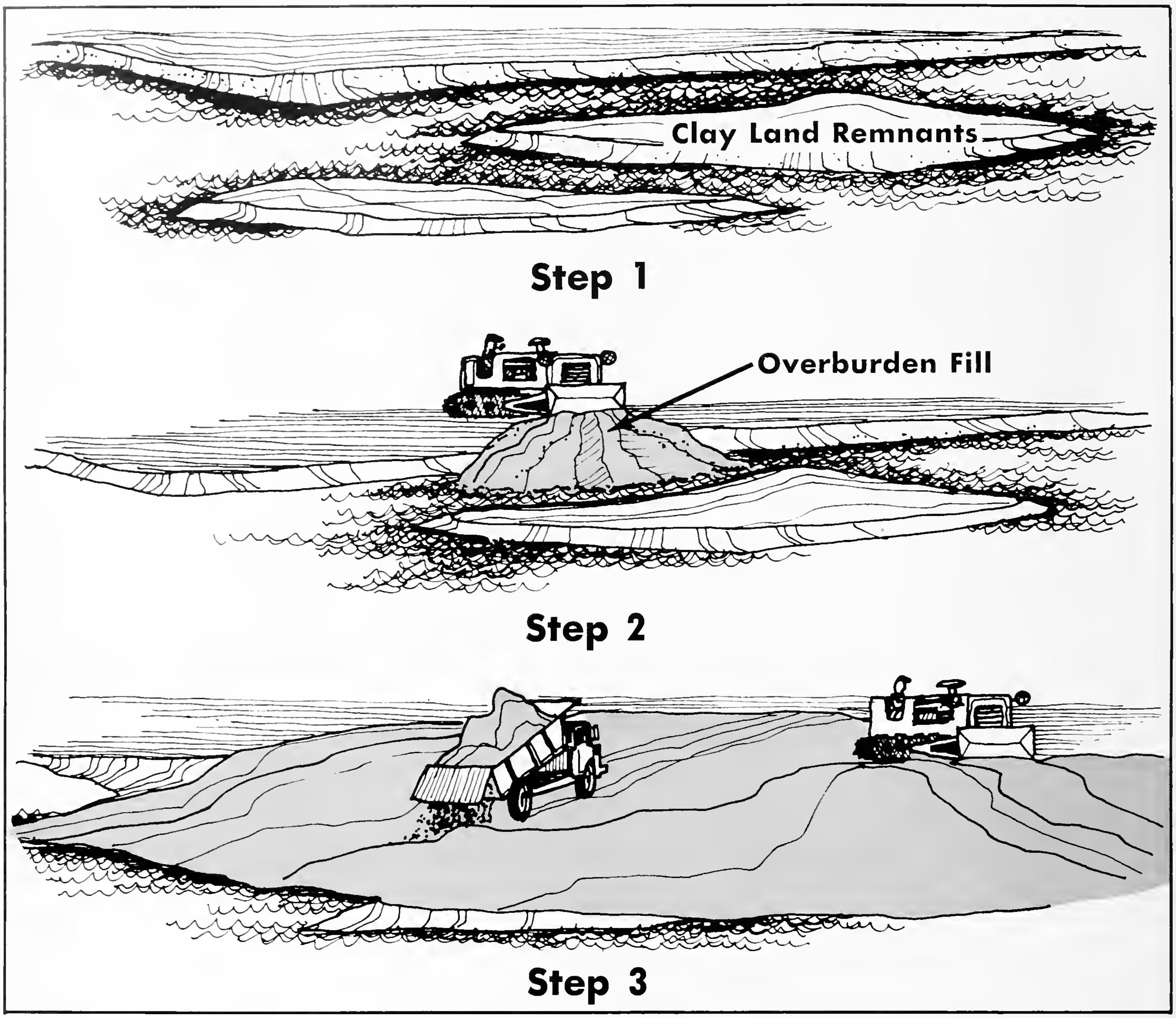


Fig. 40 — Dozer and Truck—Land Forming

poses, a width of 260 to 300 feet would be sufficient for conventional types of housing. This width would provide space for a 60 foot road with lots on both sides of 100 to 120 feet depth and an economical utility system. If the peninsula were only 150 feet wide it would have only one half as many lots as the preceding example but would require the same utilities to service the development and the utility costs per lot would be doubled. Less intense land use, such as parks, hunting and fish clubs, can use land forms of almost any shape, form or size because picnicking areas, fishing banks, hunting passes or overlooks do not have definite space requirements.

Compaction procedures, which are the steps necessary to tamp the land fill, depend upon what the land will be used for. The compaction by the dumping and grading equipment is often sufficient for less intensive land uses, such as wilderness and park areas. But if structures are going to be erected, as in the residential example above, it is recommended that the producer consult a landscape architect or civil engineer to determine the exact compaction procedures necessary to meet the specific soil bearing capacities needed to support these structures.

Dredges, Clamshells and Cable Excavators:

Excavation operations by these types of equipment are usually preceeded by stripping operations which are performed by other equipment. Since the scraper is often the tool used for stripping operations, (the other equipment), much of the above-mentioned procedure is applicable. Thus, the primary role of dredge, clamshell, and cable excavator, in water area development, is to excavate the water to a depth which will be desirable for the predetermined use. This may involve excavating below the natural depth of the deposit in a shallow deposit area, to achieve the desired depth. This is only possible if the underlying material is minable, such as clay. Thus, it may be desirable to fill shallow water areas, or leave the shallow area unexcavated on sites where excavation cannot create water areas of the desired depth.

Draglines:

Draglines strip, stockpile and excavate simultaneously and usually cast the stripped overburden back into excavated areas. On sites with deep deposits or shallow overburden, this does not present any serious problems because the amounts of ma-

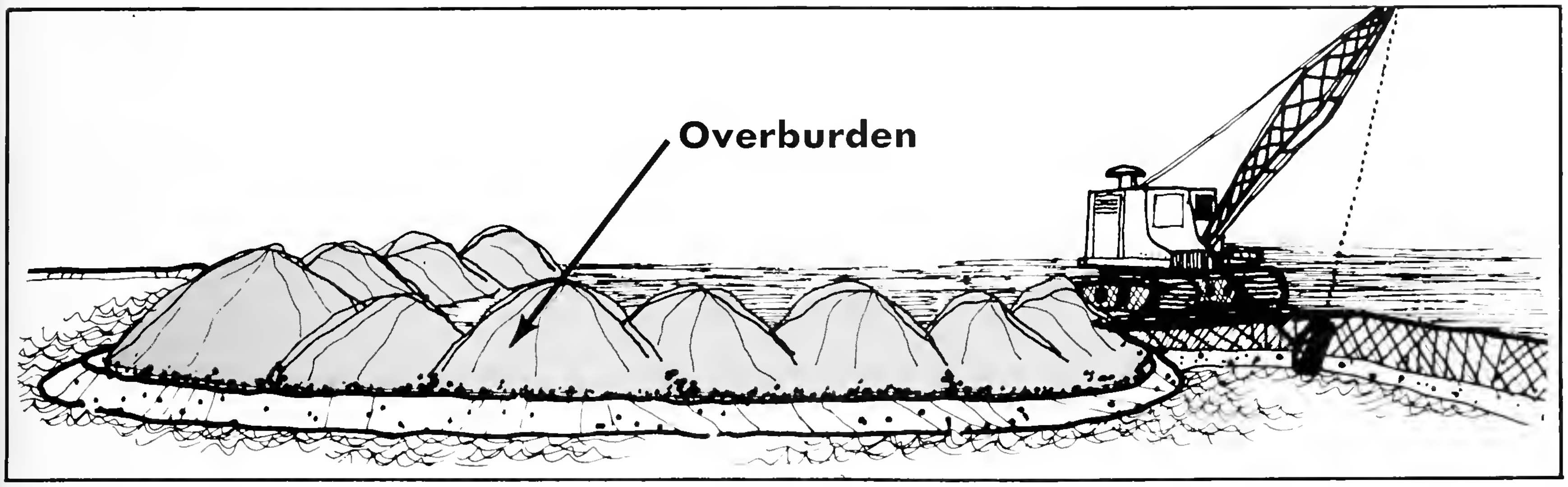


Fig. 41 — Dike Construction—Dragline

terial returned to the water will not appreciably affect water depth. On sites with large quantities of overburden, precautions should be taken to avoid filling in portions of the water area or chopping it into unusable segments with windrows of material. In this situation, best results can be achieved when excavating patterns are planned in a manner that will consolidate the overburden in specific areas and leave large open water areas. Any number of operating patterns are possible; two are illustrated. (FIG. 38) & (FIG. 39)

On both types of sites it may be desirable to utilize the dragline to load overburden into trucks instead of casting it into the water. Trucks can then haul the material to the desired land form location, dump it into the water and gradually expand the land form to the desired proportions. Bulldozers can assist in distributing the material evenly and will also help to compact the fill. The dragline, truck, dozer combination is recommended as a means of capitalizing on land remnants near shore and turning them into development assets. (FIG. 40)

If it appears, from preliminary studies, that the quantity of overburden returned into the water will be too large to create usable water areas, even if the operation pattern is altered, it may be desirable to sub-contract stripping operations to outside firms. This may be feasible on wet sites where stripping operations, with the producer's equipment, would usually create windrows of overburden in the water, destroying the aesthetic and/or functional qualities of the lake. Utilizing scrapers for stripping may mean the difference between a site with lake site lots worth $5,000 an acre, or an unusable, stagnant swamp. An example of the above procedure has been utilized by a producer in Lincoln, Illinois who sub-contracted his stripping operations to a road contractor. The contractor does the stripping job with scrapers every fall, before he puts the equipment away for the winter. The stripped overburden has been stockpiled along the shoreline, and is used for fill to form buildable land areas for seasonal cabins. After stripping has been completed, this producer has used his excavation equipment to create several beautiful lakes, one of which contains public beach facilities. If this practice appears to be unfeasible, it may be necessary to fill in the water area with overburden, fines, waste sand, or sterilized industrial or sanitary waste.

Draglines, Trucks and Scrapers — Diking

Overburden is an inexpensive material that can be used for the construction of dikes to contain waste sand for the creation of land areas out into the water. Diking is applicable on sites where a desander is standard processing equipment. For draglines, dike construction is simply a matter of stockpiling the overburden around the area where the waste sand will be deposited. (FIG. 41) Trucks can create a dike by building an enlarged haul road out into the water, which will enclose the desired waste sand disposal area. (FIG. 42)

Dikes should be located where the land forms they will create are most beneficial, either as a positive asset, such as land for development, or to remove a negative site feature such as land for development, or to remove a negative site feature such as filling in a shallow water area. Such locations

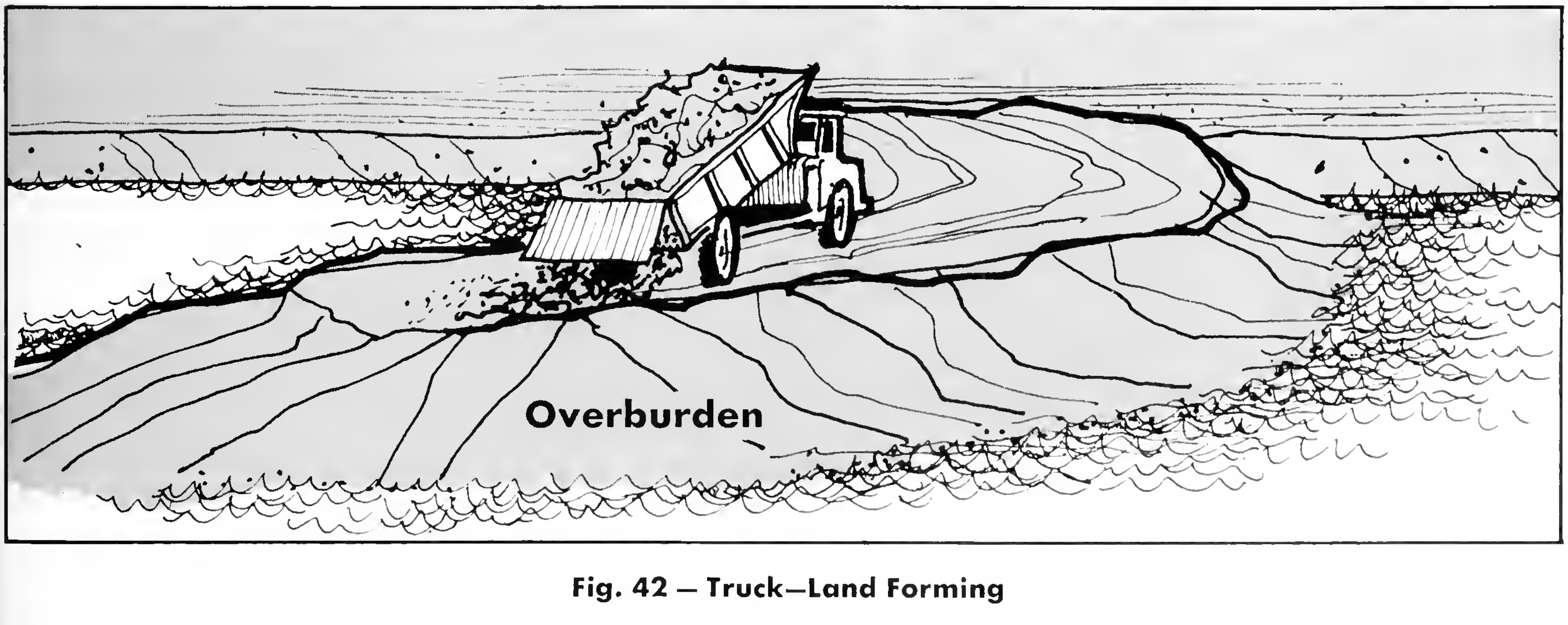


Fig. 42 — Truck—Land Forming

include the top of no dig areas, around shallow water areas, near low spots on the site, or where screening may be desirable.

No specific information is available pertaining to dike construction, such as widths or cross-section designs, capable of withstanding the pressures of wet waste sand. Since an overburden dike, constructed in the water, is similar to an earthen dam containing water, the following information from the book by Herbert L. Nichols, "Moving the Earth" may be pertinent. "The dam should be at least six feet thick at the water level and slopes should not exceed 2:1 on the downstream side nor 3:1 upstream." Dike dimensions above the water on a no dig area used in an Indianapolis rehabilitation project were: A 20 foot base, 3:1 slopes and an average height of 15 feet. Exact information can be obtained from local civil engineers or landscape architects who are familiar with local soil conditions.

Improved Operations:

Grading Plan:

It is recommended that a grading plan be developed to guide equipment operations, in preparing the site efficiently and economically for its ultimate utilization. The goals of the grading plan in terms of land forming will depend on the requirements for the site's projected land use and the esthetic objectives. Grading plans may be developed by several professions, but the landscape architect is especially trained to create sculptural land forms that are esthetically pleasing, as well as functional.

The preciseness of the grading plan depends upon the functional requirements of the future land use. Generally, accurate grading is required for the intensive land uses. For instance, a site to be developed for high density housing implies a host of utilities such as roads, walks, sewers, power lines, and parking areas, all requiring quite specific gradients which dictate a very carefully-controlled grading program. At the other extreme, a sand and gravel operation, destined for reuse as a regional park, would require accurate grading only along roads or other intense use areas with only touch up grading and replacement of topsoil necessary in the more remote areas since a somewhat rugged character is typical of this land use.

Approximate Gradients for Potential Site Users

Potential Use	Gradient Range Per Cent	Potential Use	Gradient Range Per Cent	Potential Use	Gradient Range Per Cent
Truck farm	2-4	Single family residential tracts (medium density)	2-10	Hunting resort	5-20
Nursery	2-4	Seasonal cottages	2-10	High rise residential tracts	2-30
Outdoor warehousing	2-4	Research center	2-10	Amateur missile launching area	2-30
Industrial sites	2-4	Riding club	2-10	Auto test course	2-30
Commercial sites	2-4	Country club	2-10	Missile test site	2-30
School sites	2-4	Single family residential tracts (low density)	2-10	Game preserve	2-30
Single family residential tracts (high density)	2-4	Ordnance storage	5-20	Regional park	2-50
Church sites	2-10	Golf course	5-20	Woodland	2-50
Zoo	2-10	Tree farm	5-20	Open space	2-50
Golf driving range	2-10	Camp sites	5-20		

Gradients for Site Facilities

Facility	Gradient Per Cent	Facility	Gradient Per Cent	Facility	Gradient Per Cent
Buildings	0	Minor streets	1-7	Archery range	2-10
Football fields	1	Sidewalks	1-8	Hiking trails	2-25
Softball fields	1	Driveways	1-10	Ground cover areas	2-50
Paved game courts	1	Paved patios	2-4	Swimming beach	3-4
Recreation apparatus areas	1-3	Horseshoe courts	2-4	Sled slopes	5-15
Secondary thoroughfares	1-4	Picnic areas	2-8	Ski slopes	5-25
Parking areas	1-5	Lawn areas	2-10	Motorboat launching ramp	17-26

The grading plan should be completed in two stages. Initially only a sketch plan, which specifies high and low points, drainage swales and water collection areas, is necessary to guide excavation operations. Since excavation usually extracts the deposit to its natural limits, these elevations will usually correspond with the base of the deposit. However, some earth sculpture may be required to transform the site into usable real estate property. Therefore, the grading plan may specify low areas to be filled, various slopes, treatment of pit banks to retard erosion, and the removal of unminable portions of the deposit, shaping of the pit floor or other grading procedures that may be required to accommodate a specific land use.

As excavation proceeds and the overburden is placed in the proposed locations, on excavated areas, a second stage to the grading plan becomes necessary. The second stage should be a refinement of the sketch plan to establish permanent subgrade elevations prior to topsoiling operations. To achieve the desired accuracy, this grading should be drawn correctly and to scale, showing finished contours at one or two foot intervals. It may also be advisable to make a model of the proposed contours to help in visualizing the topography.

Fig. 43 — Sloping and Terracing with Dozer and Dragline

Summary of Proposals

I. Use of Equipment
  A. Screening
    1. Scrapers
    2. Dragline
  B. Slope Development — Various Types of Equipment (Fig. 43)
    1. Controlled excavation
    2. Overburden fill
    3. Cut sloping
  C. Basegrade preparation (Fig. 44)
    1. Scrapers
    2. Boom excavators
    3. Cable excavators
  D. Water areas (Fig. 45)
    1. Scrapers
    2. Dredges, clamshells and cable excavators
    3. Dragline
    4. Draglines, trucks, and scrapers — Diking

II. Improved Operations
  A. Grading plan
  B. Approximate Grade for Land Uses

Fig. 44 — Base Grade Developed by Scraper, Seeded with Rye Grass

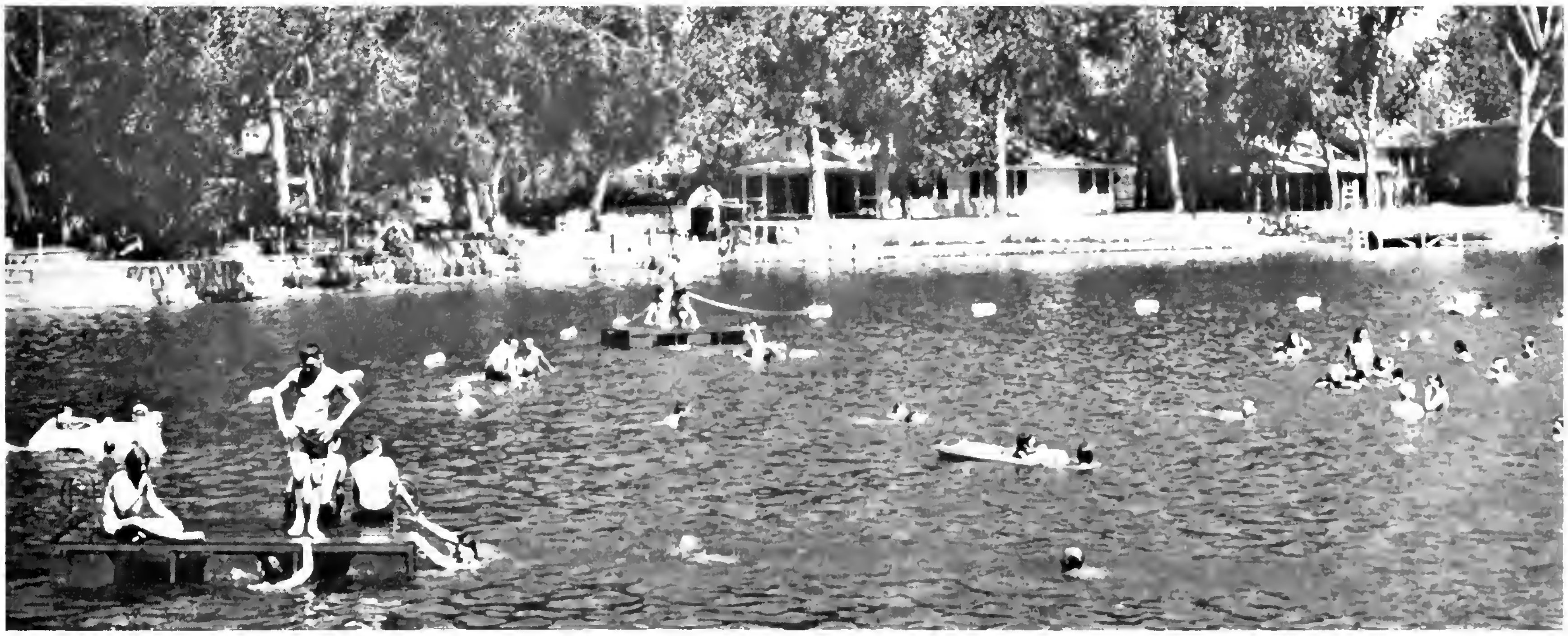
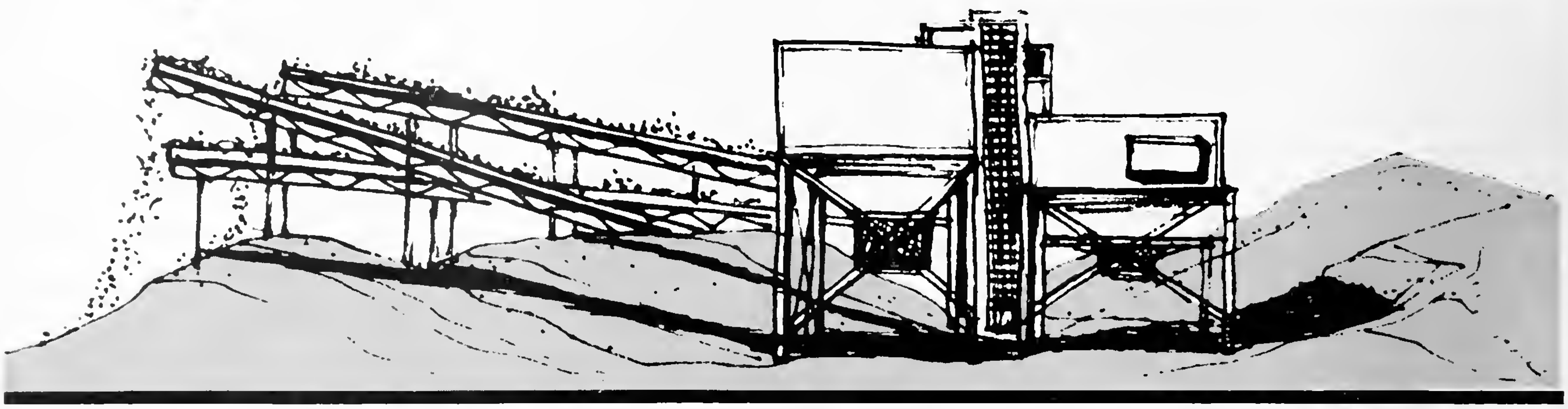


Fig. 45 — A Successfully Rehabilitated Water Area



Section 4: PROCESSING AND TRANSPORTING

Description

The processing plant is a combination of screens, crushers, classifiers, desanders, conveyor hoppers, and loading equipment forming a unit that achieves a specific rate of production and a quality grade of material. Each plant is designed to meet a variety of building material specifications. In addition to the main plant, short term operations with small portable plants may be used. Associated with the processing plant are stockpiles of material and in some cases waste sand deposits and settling basins.

In a typical plant operation the unrefined material is transported from the excavation site to the top of the processing equipment. The raw sand and gravel travels through the plant on a series of conveyors and at various stages along the route it undergoes a series of washing and screening operations. The methods of transporting the material from the excavation area to the plant are selected on the basis of site conditions and the operators preference. There are two basic modes of transportation: The relatively stationary forms such as conveyors and pipelines, which are moved infrequently if at all, and mobile forms such as trucks, carryalls, and loaders which deposit the material into hoppers that feed the material to the processing plant by conveyors. In some instances a combination of these transportation methods may be used.

Operation Results

The average area required for processing equipment, stockpiles, and transportation circulation is about 10 to 20 acres. On most sites this is a minute portion of the total operation area. However, surprisingly large numbers of nuisance problems, especially during the course of operations, may emanate from the plant area. Noise from crushers grinding the materials, the chatter of vibrating sorting screens and the clatter of sand and gravel smashing against the side of steel hoppers are noises that may carry far off the site. Dust stirred by trucks moving over roads of pulverized soil may also be carried by the wind off the site onto adjoining properties. Consequently, the processing plant has received the brunt of public criticism, especially if its appearance is disorganized and it is in a unrepaired condition that will attract attention to itself and the problems it may be creating.

On most sites the processing plant is the identifying feature of a sand and gravel operation. (FIG. 46) Its visual importance is based upon many factors. Among them are the plant relationships to the landscape and excavation area, the frequency with which the plant is exposed to view, the structural character, upkeep of the plant, and the size of stockpiles.

Plants on a flat site are exposed to view on all four sides. The massive structures and multitude of conveyors with the towering stockpiles may become colorful and exciting composition which dominate the surrounding landscape. To some sympathetic citizens the processing plant is prized as a subject for water color painting, but to the vast majority it is an objectionable addition to their community. (FIG. 47)

On hillside sites, the processing plants are usually located near to the excavation area and consequently screened on three sides by the excavation, leaving only one area exposed to be viewed. The plants visual significance is often overshadowed by the steep, vertical working face that projects above the mining area. Stockpiles of processed material are likewise lost against the dominant wall of exposed sand and gravel.

Rehabilitation Potential

There is a great deal of potential for ultimate site development in both processing and transporting operations. There is also potential for improvement of the industry's public image by a cleaning up of the appearance of the plant area, especially since the plant is regarded by a majority of the public as the symbol of the industry. Processing equipment, specifically the desander, provides material for land forming in the form of waste sand. (FIG. 48) & (FIG. 49) The desander's pumping system and pipelines are a built-in transportation network that allows the material to be deposited within the discharge radius of the pump. Thus a variety of uses for rehabilitation are possible such as: land forming, filling, and beach and shoreline development.

Proposals

Equipment Utilization:

Processing Equipment

The desander removes excess sand from the final product and is the most important item of processing equipment for ultimate land development. The waste sand can be used in

Fig. 46 — A Processing Plant That Dominates the Skyline

Fig. 47 — Character in a Processing Plant

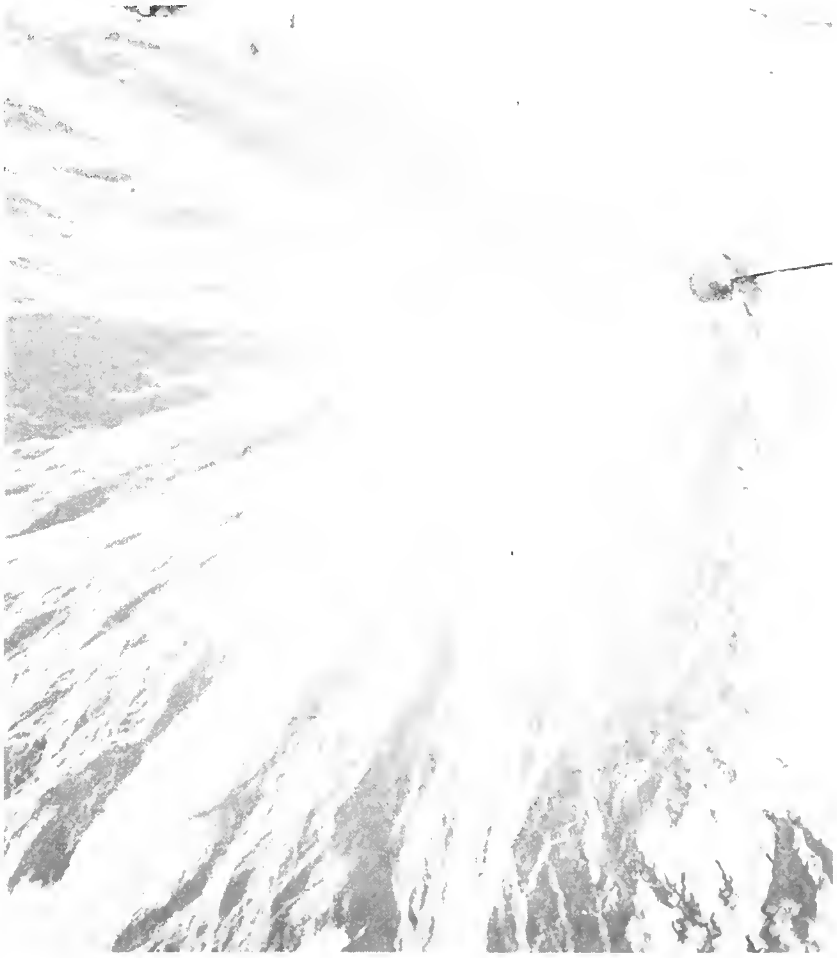


Fig. 48 — Fan Shape of a Waste Sand Deposit

Fig. 49 — Land Forming Possibilities of Waste Sand

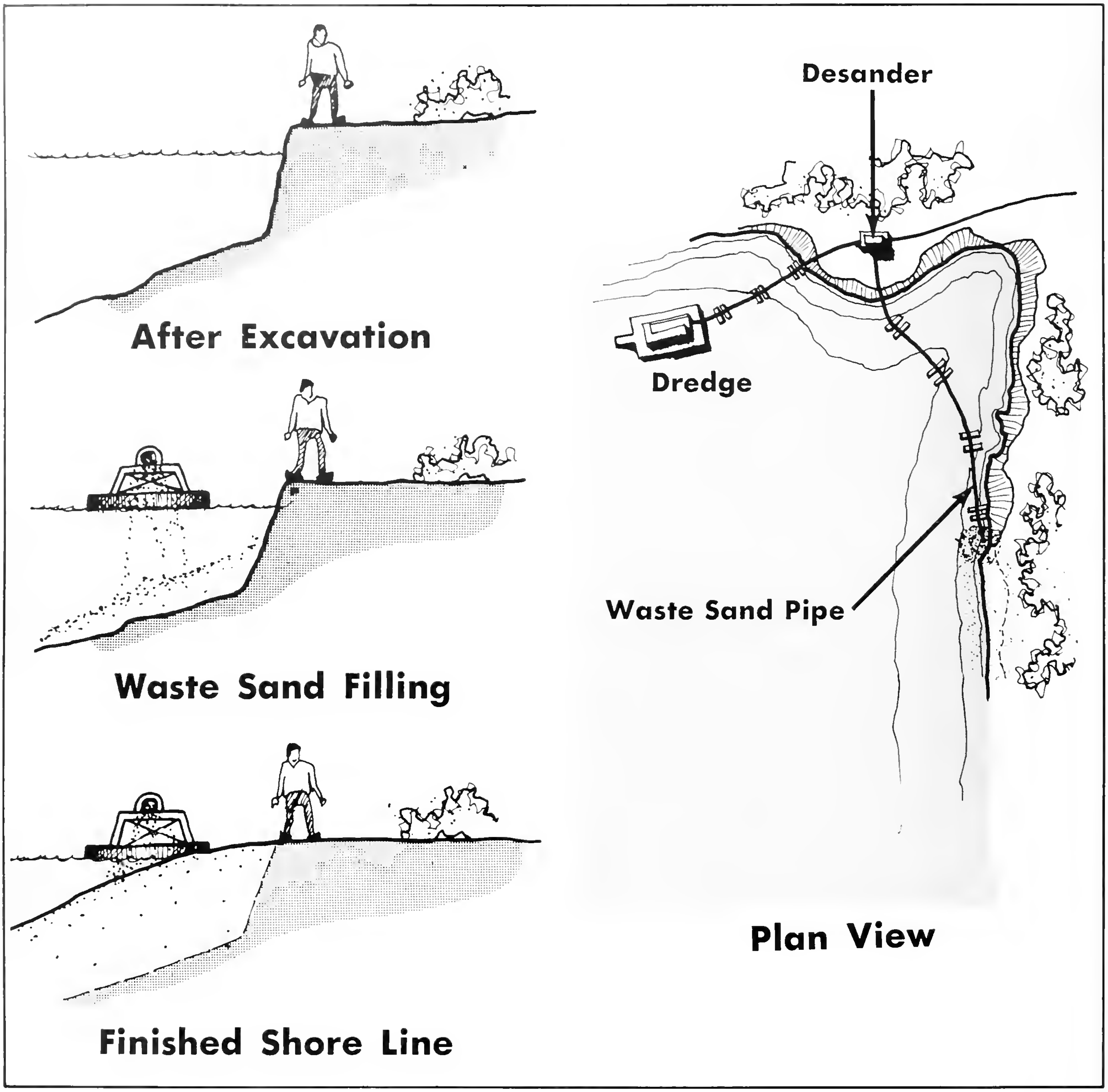


Fig. 50 — Shoreline Development—Desander

creating interesting land forms, outdoor spaces, and screening mounds to block objectionable views around the site. Processing plants which sort out fines (silt or clay) can be utilized for rehabilitation in the same manner as the desander.

The first step in utilizing the desander for rehabilitation is to determine areas where waste sand will be most beneficial for development. This will vary with each site but some suggested locations would include: areas for beach development; fill in shallow water; shoreline development; fill in low areas; and sites for buildable land forms.

The second step is to conceive methods for conveying waste sand from the desander to the desired location. In this regard pump output capacity, the maximum distance which the pump can transport waste sand, and the flexibility of the conveying pipe may become limiting factors. The desirable fill areas beyond the pump's maximum reach will have to be eliminated unless a semi-portable desander which follows excavation operations is used or in some cases it may be advisable to use larger pumps, which can move waste sand farther if, for instance, an unbuildable sliver of land can be converted into ten $6,000 home sites. In such cases the additional pump cost is usually absorbed by the increased land value facilitated by a better site development.

Beaches and Shorelines:

The affluence of clean, fine sand, discharged by normal desander operations in the immediate vicinity of the processing plant or portable desander, creates huge, wide, gently-sloping

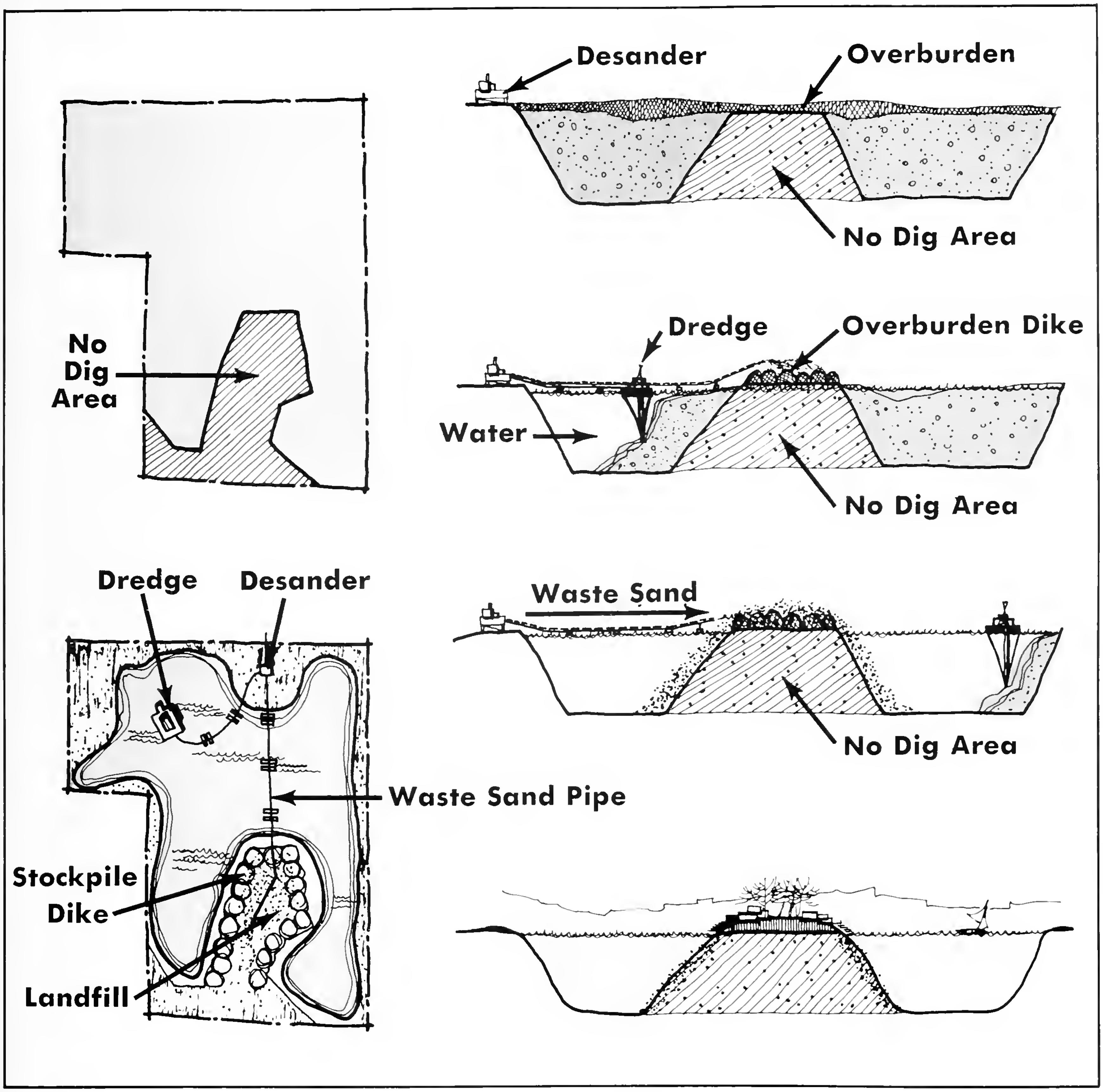


Fig. 51 — Desander—Land Forming

beaches that will rival those of the Riviera. To improve the quality of the beach, it is recommended that the discharge pipes be moved frequently to create a variety of discharge patterns and increase the lineal feet of shoreline. This is desirable since it will allow more people to be near the water's edge, (an intensely used recreation area). It will also create interesting beach forms and shallow water at a scale that is adventurous and safe for children to swim in.

Shoreline development, filling in vertical cut banks to a safe gradient, requires a lineal discharge pattern rather than the consolidated disposal technique associated with beach development. Discharging the waste sand in a pattern that parallels the shoreline would be one possible solution. The waste sand will gradually build up from the pit floor, against the cut bank, to the water surface. The width of the beach can be regulated by controlling the length of time waste sand is deposited at any one location; the longer the discharge period at one spot, the more material that accumulates and consequently the wider the beach. Once the desired beach width and gradient is achieved, a section of pipe is removed so that waste sand is deposited in a new successive location and is pumped here until the deposited material joins with the previous fill. This process is continued until the desired shoreline area is completely developed. (FIG. 50)

Land Forming:

To achieve maximum use of waste sand for land forming it is suggested that the material be pumped into some kind of

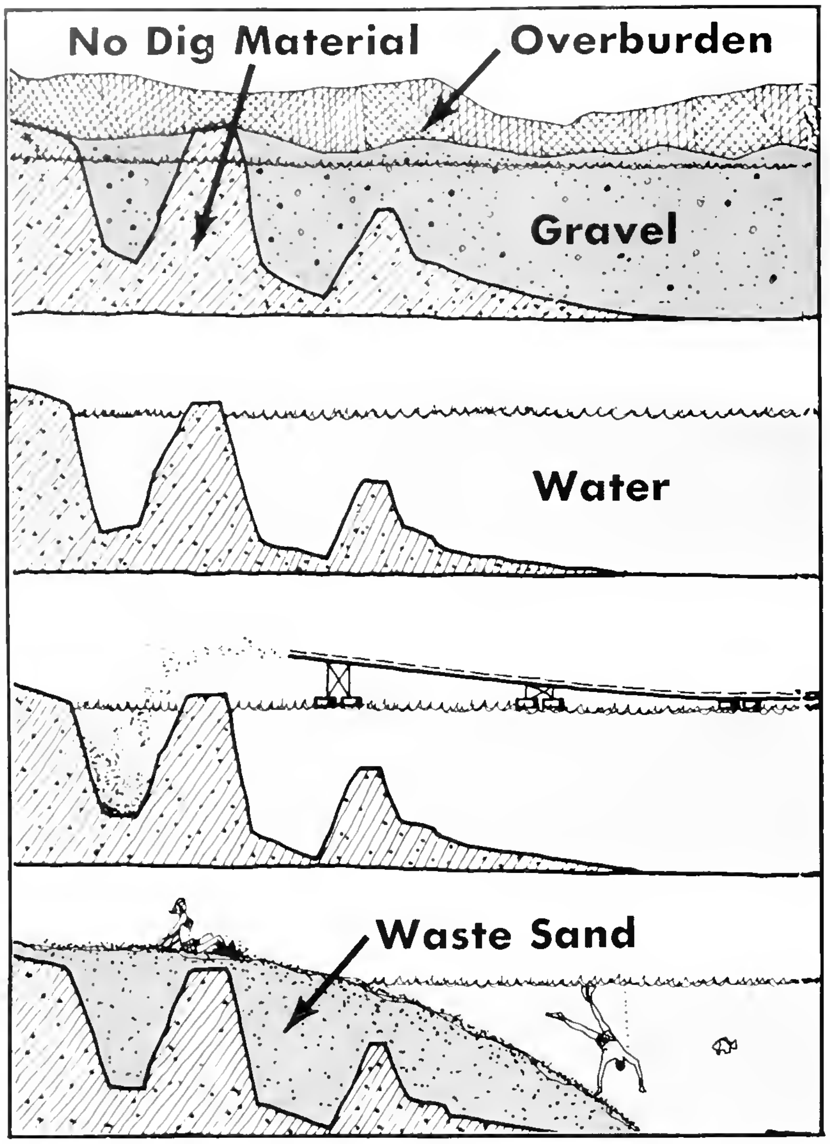


Fig. 52 — Desander—Land Forming

containing basin or behind check dams. By containing the flow of waste sand, thousands of cubic yards of material are utilized that would otherwise exist below water level as the inclined portion of the characteristic alluvial fan.

Overburden, metal, or wood can be used as waste sand retainers or check dams. Since overburden is the most economical and immediately available container material on most wet sites, its proper location will be the key to the successful utilization of waste sand. The most beneficial locations and diking construction information were discussed in the stockpiling chapter. An excellent example of a stockpile container and waste sand fill is presently being developed on a site near Indianapolis, Indiana. The operational sequence proceeds as follows: Overburden was stockpiled by a dragline on the periphery of an unminable portion of the deposit to form a waste sand container. The waste sand discharge line was placed inside the contained area and was relocated periodically until the entire area was filled. (FIG. 51)

This same principle can be used to create buildable land upon shallow water areas that may be visually undesirable or unusable for recreation or other purposes. In this situation overburden may be deposited by trucks or dozers to form a spit land around the perimeter of the shallow area and then waste sand can be pumped in behind the dike until it is filled.

The discharge pipe can be oriented so that the waste sand can be discharged behind land remnants so that they may be incorporated into the land form and converted from a visual and functional handicap to a land forming asset. The sand particles are restrained by the solid land remnants and eventually accumulate to a level above the water surface, after which the material will flow gently over the dike material and into the water, forming a gradually sloping beach. (FIG. 52)

Screening:

Waste sand can be pumped behind a series of overburden mounds to build up land areas along the water's edge. This may be desirable to prevent possible flooding of low areas or as screening to block highway nóises or objectionable views both into or from the site. The maximum height of the overburden mounds will control the height to which land areas will be elevated. Thus, by varying the stockpile heights and the distances between the stockpiles and the shoreline, interesting undulating land forms can be created.

The final step in all waste sand land forming operations is to place overburden and topsoil over the new land areas and seed it. It is recommended that these practices be performed after the material has adequately drained and been compacted.

Transporting Equipment

The uses of transporting equipment, primarily trucks for rehabilitation operations has been discussed at various times throughout the "Proposals" section of this report. In summary these rehabilitation uses would include: transporting overburden where boom type excavators are involved, to increase the possible locations for stripped material and for redistributing topsoil from stockpiles over slopes and pit floors.

Many operations have slack periods when transporting equipment may be used for the above mentioned rehabilitation uses. In some cases it may be advisable to purchase trucks for continuous use in rehabilitation to supplement this periodic assist. The purchase price will usually be returned with interest in the form of increased land values for the depleted site.

Improved Operations

Plant Location

The first suggested step toward eliminating complaints about noise and dust problems, commonly associated with processing operations, is to select the best possible location for the processing plant. The location should satisfy the plant's functional requirements of close proximity to transportation arteries, space for storage yards and settling basin if required, and room for vehicular circulation, and be as unobjectionable as possible. A few sites have an ideal location, downwind from surrounding development, secluded by vegetative and topographic screening and meeting all the previously mentioned functional requirements. However, most sites do not possess such an optimum location, therefore, it is necessary to consider such factors as prevailing wind directions, location and types of surrounding land uses, existing topographic variations and vegetation suitable for screening, access requirements, and deposit characteristics, so that a location which embodies the maximum number of characteristics that will help to alleviate the problems associated with processing can be selected. This will require a thorough study and analysis of the site information, and the location selected. A sand and gravel firm in the Ohio area is attempting to locate their processing plant at the bottom of their pit where they are out of sight and much of the noise and dust is contained by the pit walls. This is an excellent solution to nuisance problems; however, it requires digging a pilot trench in the area where the processing plant is to be located. The material removed from this trench has to be rehandled and trucked to the processing plant after it is constructed.

Screening and Composition

Since the majority of processing plant locations will not meet the requirements for an ideal plant location, it is recommended that an artificial environment be created embodying the maximum number of nuisance-controlling features. (FIG. 53) The most expedient way to accomplish this objective is by the development of a screening program that would utilize vegetation, overburden from stripping operations and stockpiled sand and gravel to: 1) Confine dust to the plant area. 2) Baffle noise. 3) Hide objectionable processing plant features.

Trees, shrubs and grasses should be planted along haul

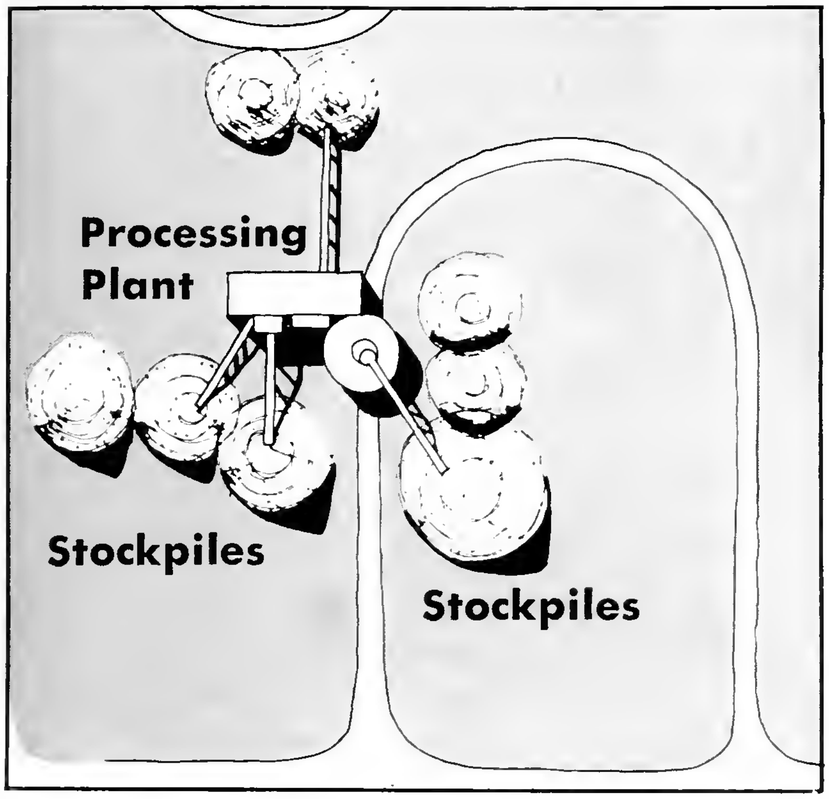


Fig. 53 — Step 1—Typical Plant Area

roads leading to and from the processing plant and around the plant area to act as a barrier to operation noises. Planting and conservation practices along the site periphery as suggested in the clearing section are effective as a secondary dust barrier and a muffler of sound transmissions. (FIG. 53a)

Stock piles of overburden should be deposited around the processing plant out of the active operating area, and graded into low-mound forms by dozers, loaders, or graders, or deposited initially in this form by scrapers to act as screening for storage areas and maintenance yards. These can be seeded with various cover crops to control weeds and improve appearance. An interesting effect could be created by planting colored masses of sweet clover in various compositions.

Mounds in the form of surge-stockpiles are created by the processing plant in the performance of normal refining operations. It is suggested that the surge piles be utilized for screening purposes. To achieve maximum screening effectiveness, surge piles should be placed in the most beneficial locations, for example, to block a vista or as an intermediate sound barrier between the plant and surrounding development. (FIG. 53b) This can be achieved by planning the orientation of the processing plant prior to its construction so conveyors will discharge the refined materials in the desired location.

There are numerous possibilities for creating landscape design forms or patterns by combining all three of these screening elements—the variety of plant forms and textures, the grainy textures of the vertically oriented surge piles, and the low undulating mound forms of overburden. They would improve

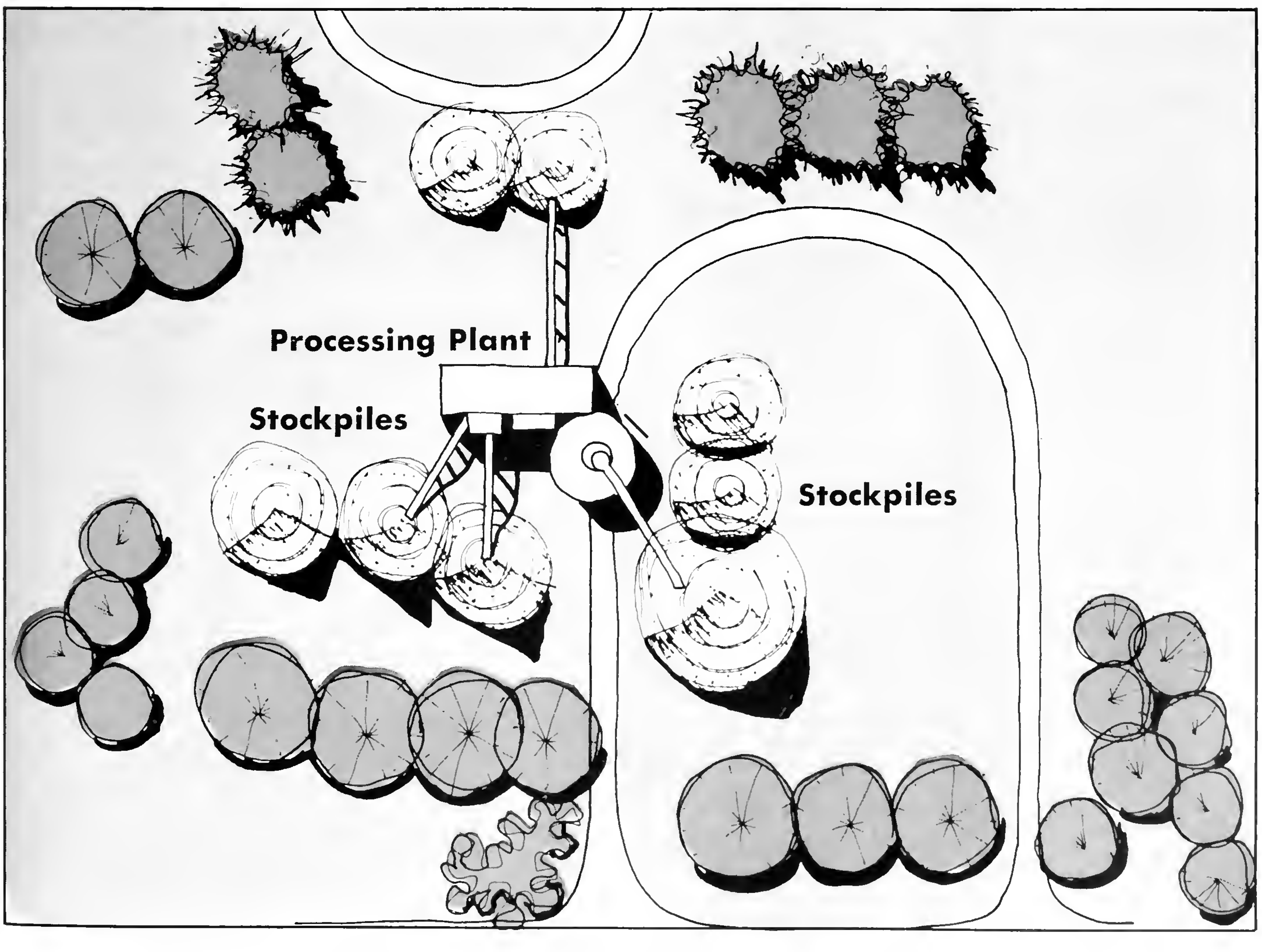


Fig 53A — Step 2—Addition of Screen and Frame Planting

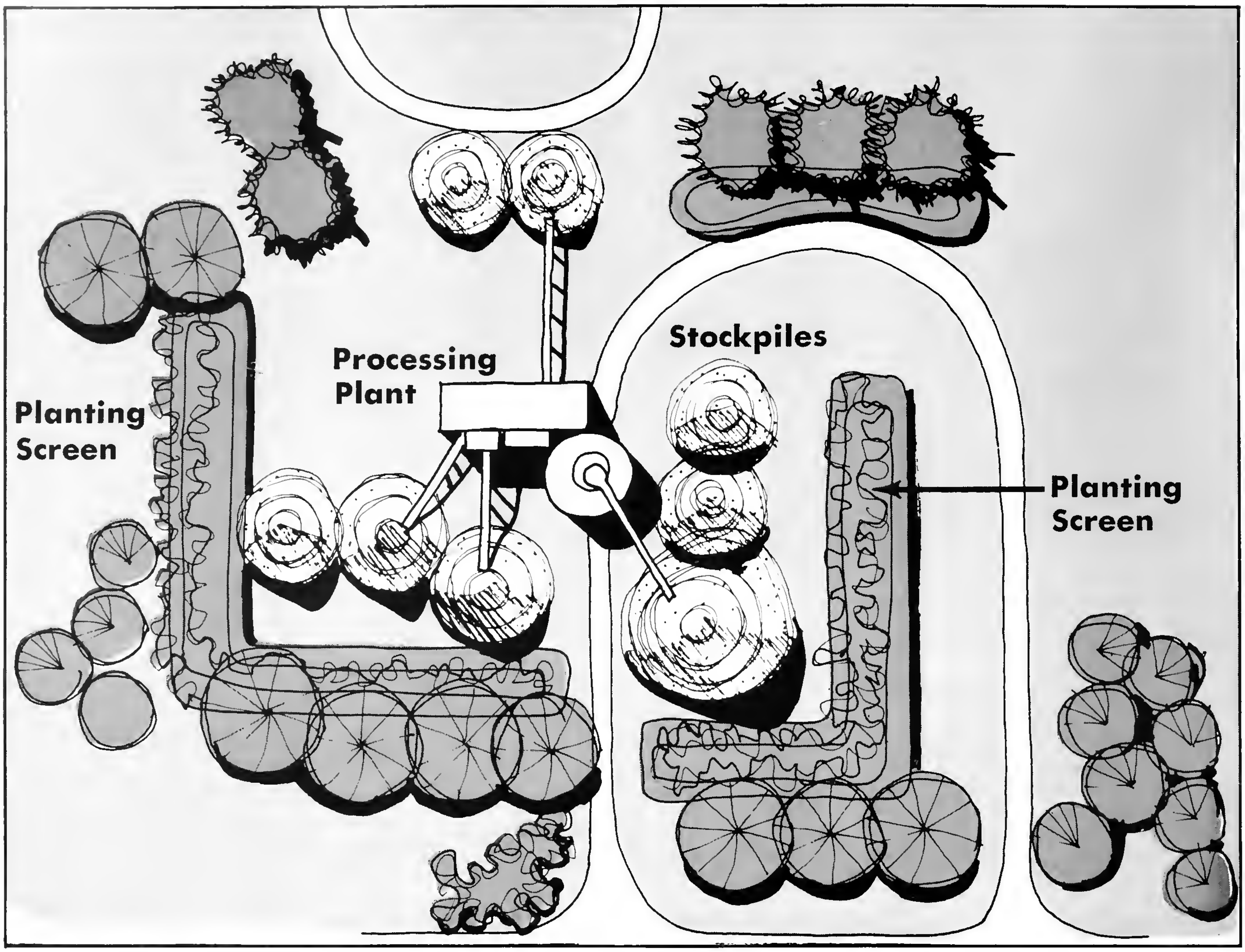


Fig. 53B — Step 3 — Addition of Screening Mound

Fig. 53C — Step 4—Sketch of Total Composition

Fig. 54 — Land Forming with a Desander

immensely the appearance of the processing plant area as well as reduce plant nuisance problems. (FIG. 53c) The spaces enclosed by these mounds and vegetation could become a focal point for future site development after operations are terminated and the plant disassembled, because the plant area is usually near the main entrance to the site. For example the vacated plant location would make an excellent site for a community center in a residential development or as the office area for an industrial complex.

Good Housekeeping and Embellishment

Composing interesting frames of plants and mounded material doesn't make much visual sense when the focal point, the processing plant, is unpainted, in need of repair, and the ground surface is cluttered with worn out parts and discarded equipment. The success of any processing plant improvement program must include continuous good housekeeping practices. This means the removal of derelict equipment, some semblance of order in the storage areas, a weed control program and a periodic maintenance program to clean the processing plant.

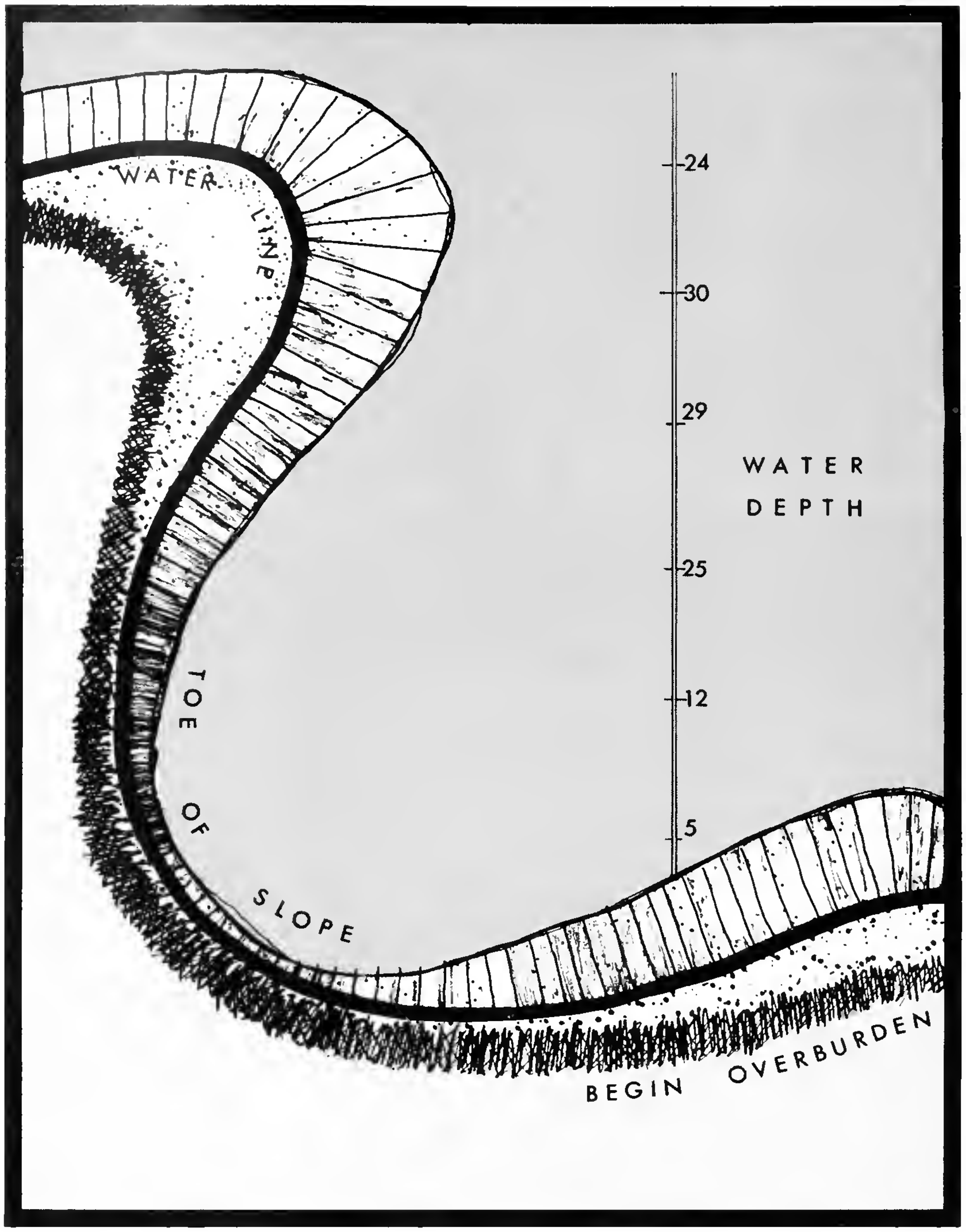
Painting suggests some interesting possibilities. One approach would be to paint the plant a neutral color or a color which would blend well with its surrounding, thus making the plant as unobtrusive as possible. For example a smoky green color could be used for processing plants in forested areas or a buff brown used where the landscape character is dry and sandy. Another approach would be to exploit the principle of contrast which makes red barns such a welcome relief from green of the rural landscape. This would suggest that bright bold colors in pleasing combinations be used to accent the structural features of the processing plant. Many European sand and gravel producers have used this approach quite successfully.

Dusting, or rather eliminating dust, is another housekeeping practice essential to good neighbor relations. Haul roads were listed in the Schreibeis and Schrenk report in "Evaluation of Dust and Noise Conditions at Typical Sand and Gravel Plants" as primary sources of dust. This suggests that haul roads should be paved, watered or oiled, and maintained in as dust free condition as possible.

Clean up, after operations are completed, is also essential. This should entail the removal of all discarded equipment and parts and grading waste piles to uniform grades, covering with overburden, topsoil, and seeding with a cover crop.

Summary of Proposals

1. Use of the desander for: — (Fig. 54)
   A. Beach and Shoreline development
   B. Land forming
   C. Screening
2. Use of transportation equipment
   A. Slope development
   B. Basegrade preparation
3. Improved operations
   A. Planned processing plant location
   B. Composition of screening
   C. Good housekeeping and embellishments



Chapter 3

Case Study

The case study is presented to illustrate how planning procedures and the application of equipment and operations can be utilized to progressively develop a sand and gravel site into usable real estate. The Littleton site, Three Lakes Community operated by the Cooley Gravel Company of Arvada, Colorado, was designated as an operation typical of the sand and gravel industry and excellent for the research objectives of this report.

Background

Location:

The Three Lakes Community site is located eleven miles south of Denver, Colorado, the hub city for the Central Rocky Mountain Region. Denver is one of the most rapidly growing cities in America. Its present population is 880,000 and it is estimated that it will be over 1,000,000 by 1970.

The project location is adjacent to the South Denver suburb of Littleton, population 17,000 — a figure that is expected to double by 1970 according to the projections made by the Inter-County Regional Planning Commission. Littleton offers excellent shopping facilities, numerous churches and a progressive school system, within a 5 minute drive or 20 minute walk from the site. Most of Littleton's residents commute daily to work in Denver so Littleton serves as a "bedroom suburb."

Site Characteristics:

Topography — (FIG. 55)

The site consists of 250 acres of relatively flat terrain sloping ten feet from the upper southeast corner to the lower northwest corner. The South Platte River flows from south to the north paralleling the site's east boundary. During the spring months the river may overflow its banks covering 80 percent of the site with water two or three feet deep.

Vegetation — (FIG. 55)

Lowland-associated plant species such as cottonwood, elms, willows, and boxelder flourish in unexcavated areas and waste-heaps. Presently this vegetation screens the view from Columbine Estates to the excavation area. Natural growth of vegetation on rehabilitated portions of the site appears to be spotty with better growth occurring near water areas.

Fig. 55 — Typical Vegetation on the Cooley Site

Access

The major access to the site is by a dirt road from the east which is an extension of Jackass Hill Road. County planning officials have proposed that this road be paved and extended through the site as a major east-west throughway with a 150 foot right of way. South Sante Fe Drive to the east of the site is a major north-south route into Denver. A new highway was tentatively planned to replace the South Sante Fe Drive. The new road will parallel the east side of the South Platte River and roughly follow the course of South Sante Fe Drive. Levees have been recommended along the river to control flood waters and protect the proposed highway and surrounding lands.

Land Use

Three Lakes Community is located in an agricultural suburban transition zone which is rapidly changing from an agricultural land use to a low or medium-density residential use. Columbine Estates, an exclusive golf course subdivision, is just north of the case study area. Various smaller subdivisions are under construction northeast and northwest of the site. Agricultural land uses surround the site on the east, south and west.

Views — (FIG. 56)

Views into the site are not presently objectionable but they may soon be. The critical area is the north end of the site bounded by Columbine Country Club. There will be no vegetative or topographic obstructions of the view from Columbine Estates to the excavation area once clearing operations have removed the existing vegetation in the north quarter of the site. As operations near completion the dredge and processing plant, plus the continuous line of trucks, will be near enough to the Estates for noise and dust to become a nuisance unless steps are taken to protect against these problems. There are also several areas along the Sante Fe Drive and Platte Canyon Road from which the excavation area can be viewed but the lakes appear as the dominant operational feature and are not objectionable.

The quality of views from the interior of the site to the surrounding landscape are varied. Views to the east focus on South Sante Fe Drive and its traffic. To the north the interesting landscape design of Columbine Estates come into perspective. The most spectacular views from the site are of the foothills to the south and west. The low ridges of mountains are counterpoint accents opposed to the flat profile of the plateau that contains the proposed development. At sunset the mountains form a breath-taking composition with the sky which lends a rich atmosphere to the area.

Controls

The Three Lakes Community is within the zoning jurisdiction of the Arapahoe County Planning Commission. Presently the sand and gravel operation has been designated as a permitted land use. No operating restrictions or performance standards

Fig. 56 — View West to the Mountains

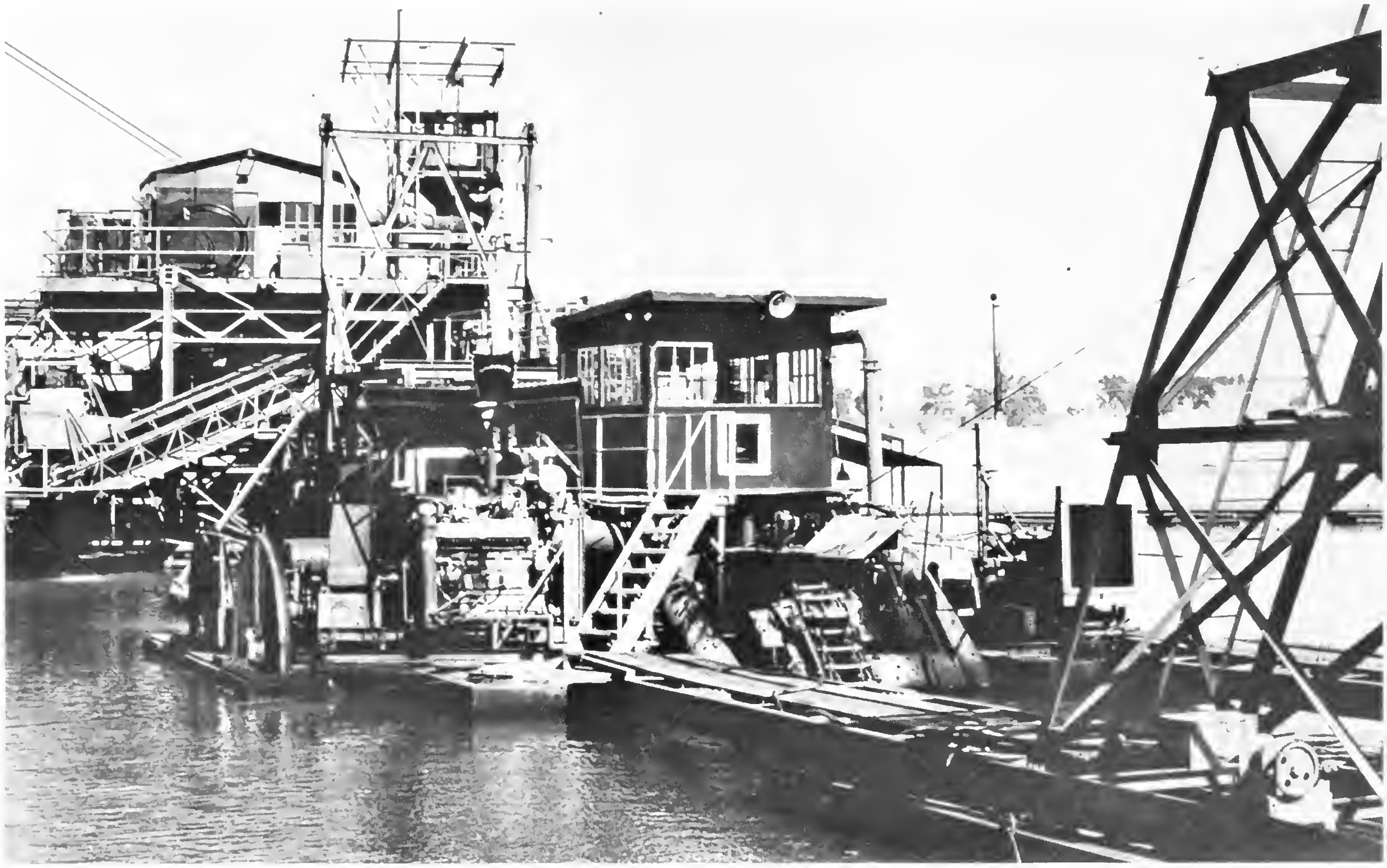


Fig. 57 — Cooley Company Dredge

affect it. For re-use, the site has been zoned for low density residential development allowing two dwelling units per buildable acre.

Deposit Characteristics

The deposit varies in depth from 18 to 55 feet with the shallower deposits nearer the river. The base of the deposit is a thick stratified bed of shale. The amount of sand in the deposit varies from 40 to 60 percent with no definite location of areas with high sand content. There are approximately 2,000,000 cubic yards of overburden for subgrade material. The water table is 3 or 4 feet below the surface and drops to 10 feet below surface during the summer. The water in the lakes has percolated through sand and gravel deposits to the south of the site. The sand and gravel has removed silt and other foreign matter and consequently the water is clean, pure, and safe for water recreation.

Operations

The Cooley Company operations involve the use of a dredge with a processing plant on board to excavate the material. (FIG. 57) The sand and gravel is sucked by a vacuum pump on the dredge through the intake pipe and into the processing plant. The processing plant refines the material and the finished product is conveyed to a dry land area ahead of the cut bank, while the waste sand is discharged from a desander into the excavated area. (FIG. 58)

A system of unexcavated zones are used as dikes to control the lake levels. Control valves connect the lakes so levels can be raised or lowered as desired to facilitate excavation operations.

The dredge operates in a lineal pattern perpendicular to the submerged working face and parallel to the cut bank. One digging pass is completed after the dredge has made an excavation cut across the property in an east west direction. When one pass is completed, the cutting bit and suction pipes are removed from their coupling and reassembled to a similar coupling at the opposite end of the dredge and then it proceeds back across the site. This procedure is repeated until a dike is reached. At this point the machine is taken over the dike to a new starting point and operations continue as before.

Objectives:

The Cooley Gravel Company's operation and equipment were analyzed for rehabilitation potential and the following basic objectives were outlined:

1. To utilize the desander and the waste sand it disposes of as a by product of the processing operation to create sculptural land forms that can be built upon.
2. To create large bodies of open water for recreation by altering the operation to consolidate deposit areas for waste sand.
3. To minimize the handling of topsoil and overburden by utilizing the scraper, that is performing stripping operations, to deposit it directly in place on constructed land forms of waste sand.
4. To progressively develop the site in the following sequence:
    a. Excavate
    b. Create land forms with waste sand
    c. Cover land forms with overburden
    d. Cover land forms with topsoil
    e. Seed cover crop
    f. Survey for roads and utilities
    g. Plant trees and shrubs
    h. Seed aquatic vegetation
    i. Stock lakes with fish
    j. Construction of roads, utilities and housing units.

Operation Proposals:

1. Installation of a larger waste sand pump in the desander was proposed so that waste sand could be transported over a longer distance, 600 feet, instead of the present pumping range of 300 feet. This would provide a greater opportunity to consolidate land forms by transporting more material to each land form area so that surface elevation could be brought above flood level. By consolidating land forms, water bodies would become larger and would have an interesting undulating shoreline. These characteristics are desirable for residential development and water sports because they form a constantly changing and exciting landscape.
2. Some alterations in the operating pattern were made to facilitate the creation of the proposed land forms. These alterations were suggested because the continuation of present operating patterns would create long, narrow ditch-like lakes that are not desirable for development. The proposed alterations would involve some additional expense to the Cooley Company because of increased downtime for equipment changes resulting from increasing numbers of variations in the digging patterns. It was felt that expense could be justified because the rehabilitation costs would be absorbed by the increased land value brought about by the creation of a better environment for development.
3. It was proposed that the present stockpiling plan, adopted by the Cooley Company, prior to this study, be continued. This plan included the stripping of one year's excavation, and depositing the overburden and topsoil on the waste sand land forms in depths of six inches to three feet.
4. The adoption of a two part planting program was proposed. First the installation of a planted screen along the north and west edges of the property, to insure that screening for Columbine Estates will be available, once clearing operations have removed the existing vegetation which presently screens the site. Second, planting a cover over areas that have been, or are being, topsoiled to prevent erosion and to build up the soil structure and nutrient levels.

Design Proposals:

The proposed use for the site was a community of 212 dwelling units on 106 acres of sculptured land, surrounding 100 acres of water. These land uses and densities comply with the requirements, as specified in the Arapahoe County Master Plan and the regional proposals of the Inter-County Regional Planning Commission, which has extensively studied the area.

Facilities:

Within the community, a variety of housing types were proposed to allow residents the maximum choice in living environment. In similar developments, young couples have preferred town house and high rise living. Families with children have tended toward the single family detached homes. It was felt that this heterogeneous social composition would add cultural and social vigor to the community.

The residential high rise building was located where it would command a view of the mountains to the west. The view would be quite spectacular when seen across a half mile of water as foreground, and an orange and purple sunset as background. The high rise is located in an area with bedrock only 18 feet from the surface so footing expense could be minimized. It was felt that the vertical proportions of the high rise structure would be the focal point to the community.

A community center, and a small convenience shopping facility were provided to service the anticipated 600 residents. This area could serve as the hub for any social activities. Boat docks were provided in conjunction with this building complex to encourage use of water transportation. A system of small electrically operated track cars would allow boats to be shuttled from one lake to another. Littleton would serve as the regional shopping center and would also satisfy the needs for schools, churchs and other public and semi-public services.

Fig. 58 — Land Forming with Waste Sand and Grading of Overburden in the Background

Circulation:

The main circulation route into the development would be along the eastern edge of the site off the proposed extension to Jackass Hill Road. This location, paralleling the base of the levee, would keep the majority of cars out of the interior portions of the development, where the single family detached homes, with children, would be most prevalent. High density housing units are located close to the main circulation routes and thus are immediately accessible. This also helps to confine high volumes of traffic to a minimum road area. Minor circulation routes feed off the main artery like veins in a leaf, becoming smaller as they branch off to serve clusters of homes.

The peripheral roads on the north and west sides of the site are proposed along the property line for two reasons. (1) It would give surrounding land owners the opportunity of using the road and the utilities in their development plans. Thus, construction costs for roads and utilities could be shared by the Cooley Company and the abutting developers. (2) With the road at the rear of the lot, pedestrian movement between the residential units and the water area is not impeded.

Recreation:

A 61 acre park was developed south of Jackass Hill Road. The city of Littleton already owns a large portion of this area for well sites. It was felt that a good public relations venture would be to donate or sell the remaining portion of the site to the county for park space. The park has excellent access to Jackass Hill Road, and offers sandy beaches seldom found in the Denver area. The park would be connected with Littleton by a system of trails and bike paths along the levee so youngsters could travel to and from the park by themselves. A small rowboat marina was proposed, in conjunction with the beach, so that the small islands could be developed for picnic purposes. The Arapahoe County Planning Commission felt this type of park development would be very desirable in this location.

The lakes will be stocked with a quantity of game fish including bass, blue-gills and crappies. Shallow water areas in the eastern portion of the site, paralleling the main entrance road are proposed to be left undeveloped so such areas could be planted with aquatic plants to establish fish spawning areas. Thus, the fish could maintain their own population level without frequent restocking.

DESCRIPTION OF DRAWINGS

Orientation Sheet

The orientation sheet locates the site and its area of influence within the Denver Region and illustrates the relationship of the site to the land use that occurs along the South Santa Fe Drive from the Denver Central Business District to the rural landscape.

Site Analysis

The site analysis is a graphic representation of the various natural and cultural factors such as vegetation, surrounding land use, and flood levels that affect the site. This sheet of information is the basis for many of the land development proposals made in the master plan.

Deposit Analysis and Sections

These three sheets are an analysis of the deposit characteristics: depth, quantities of sand and gravel, and quantities of overburden. The legend on the deposit analysis sheet describes what each contour line represents. The sections illustrate the information on the deposit analysis sheet.

Concept Drawing

The concept is a diagrammatic sketch of design thoughts and relationships. It represents in abstract form a design synthesis of all the site, deposit, and operation information.

Master Plan

This drawing is an articulation of the concept in physical form, drawn accurately to scale and illustrating landforms, roads, parking areas, structures, waterbodies and elevations.

Model

The model was constructed as a three dimensional study of the masterplan. By mentally shrinking in scale one can place himself in the model, sense the spatial sequence along the roads and walks, feel the relationships between buildings and the landscape and thus critically analyze the design as a spatial and functional composition.

Sketches

The primary purpose of the sketches is to illustrate the character of development that is anticipated.

Quantities

This drawing illustrates the cubic yards of waste sand necessary to create the proposed land forms. The dashed lines delimit the area of the existing deposit that will supply the required quantities of waste sand. The arrows show the direction of disposal required for the desander to dispose of waste sand.

Operations

The operating plan is based on a maximum pumping distance of 600 feet for the desander. Consequently, the maximum distance for dredge digging operations is 600 feet from the outside edge of the land form that is reusing sand from the desander. The operations drawing illustrates the patterns of excavation required to deposit waste sand in the desired location. This operation pattern fulfills the quantities of waste sand expressed in the quantities drawing.

Staging

This sheet identifies the areas to be developed according to a time sequence schedule and what types of development should occur during the course of sand and gravel operations.

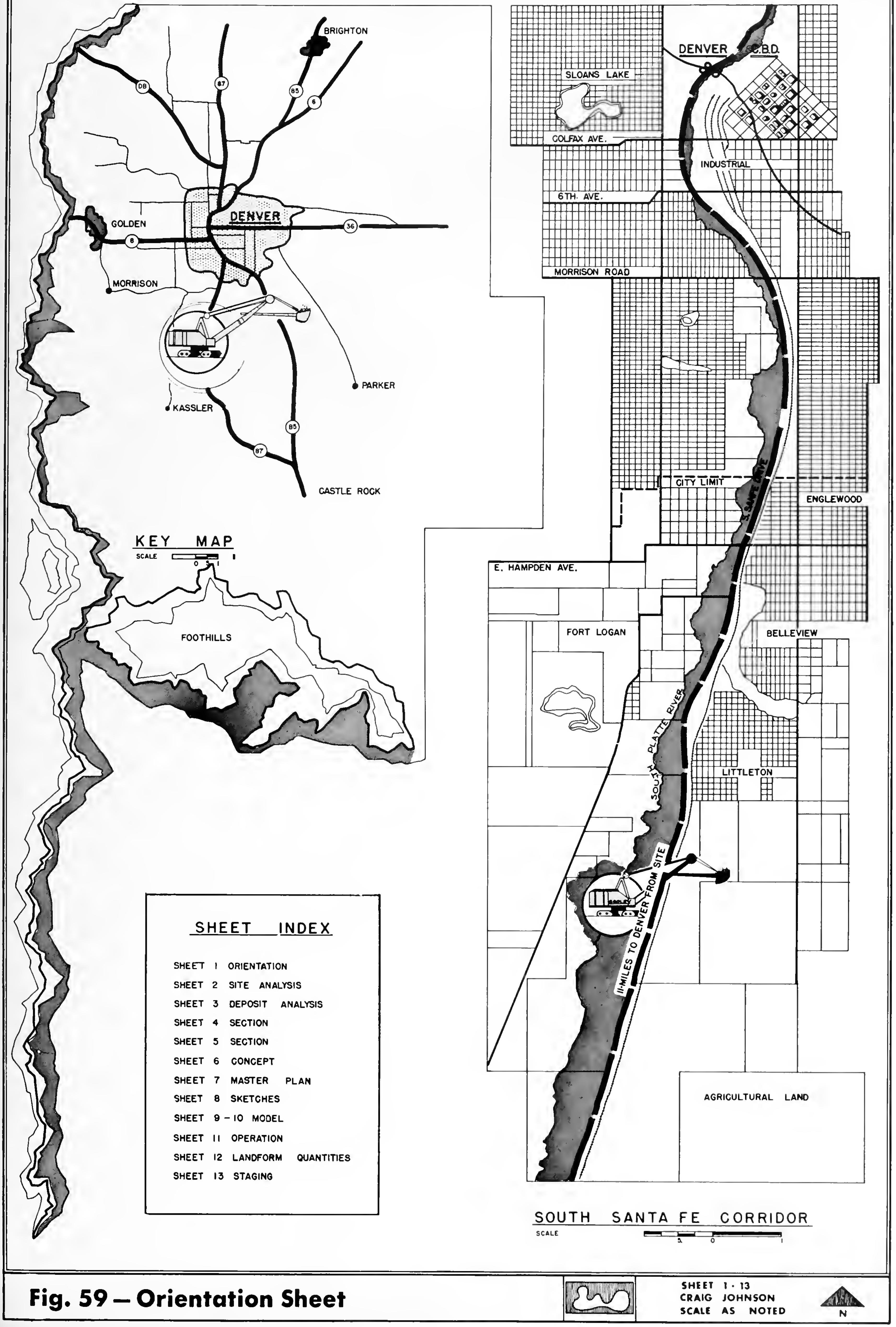


Fig. 59 — Orientation Sheet

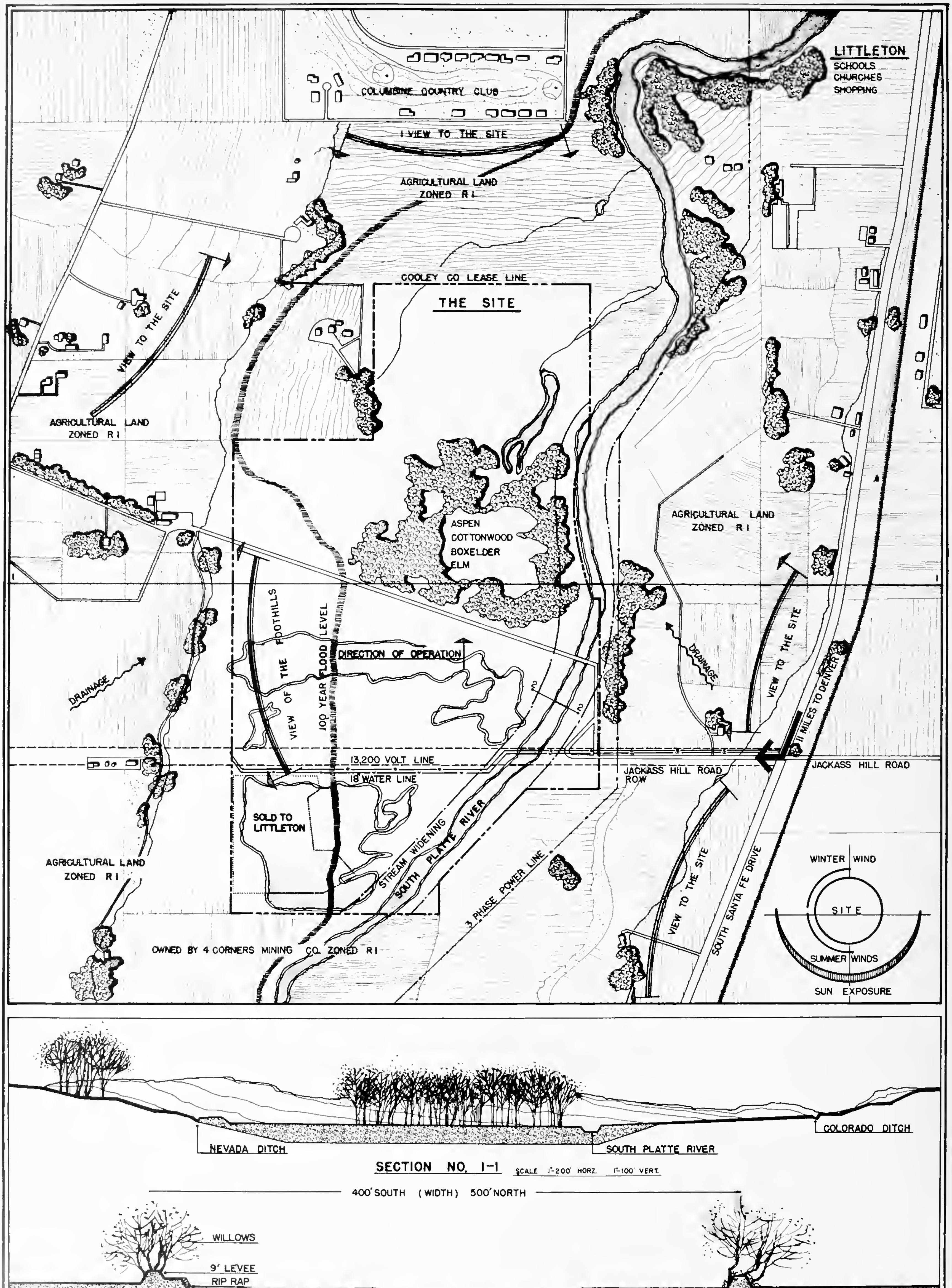


Fig. 60 — Site Analysis

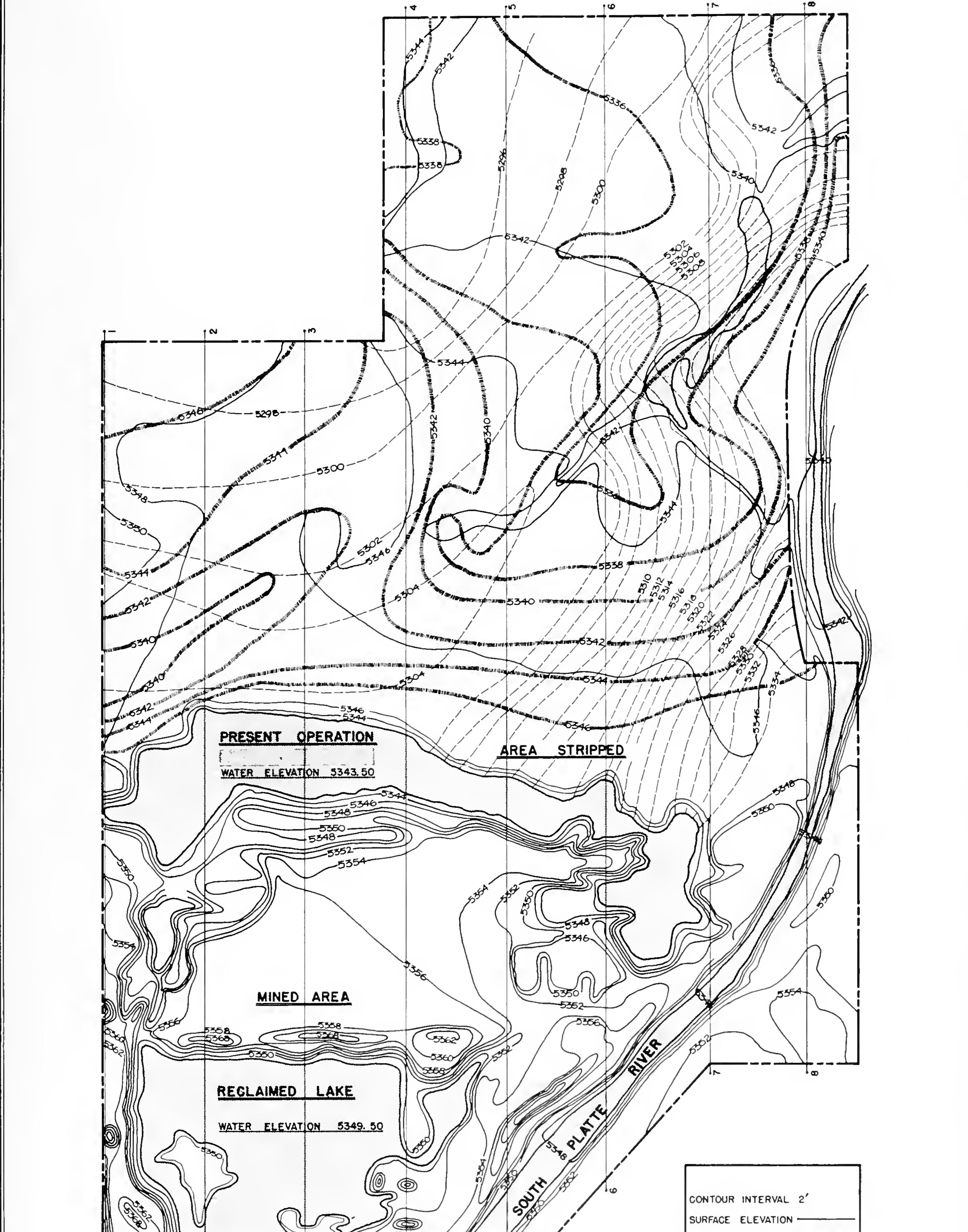


Fig. 61 — Deposit Information

SHEET 3 - 13

SCALE 1" - 200'

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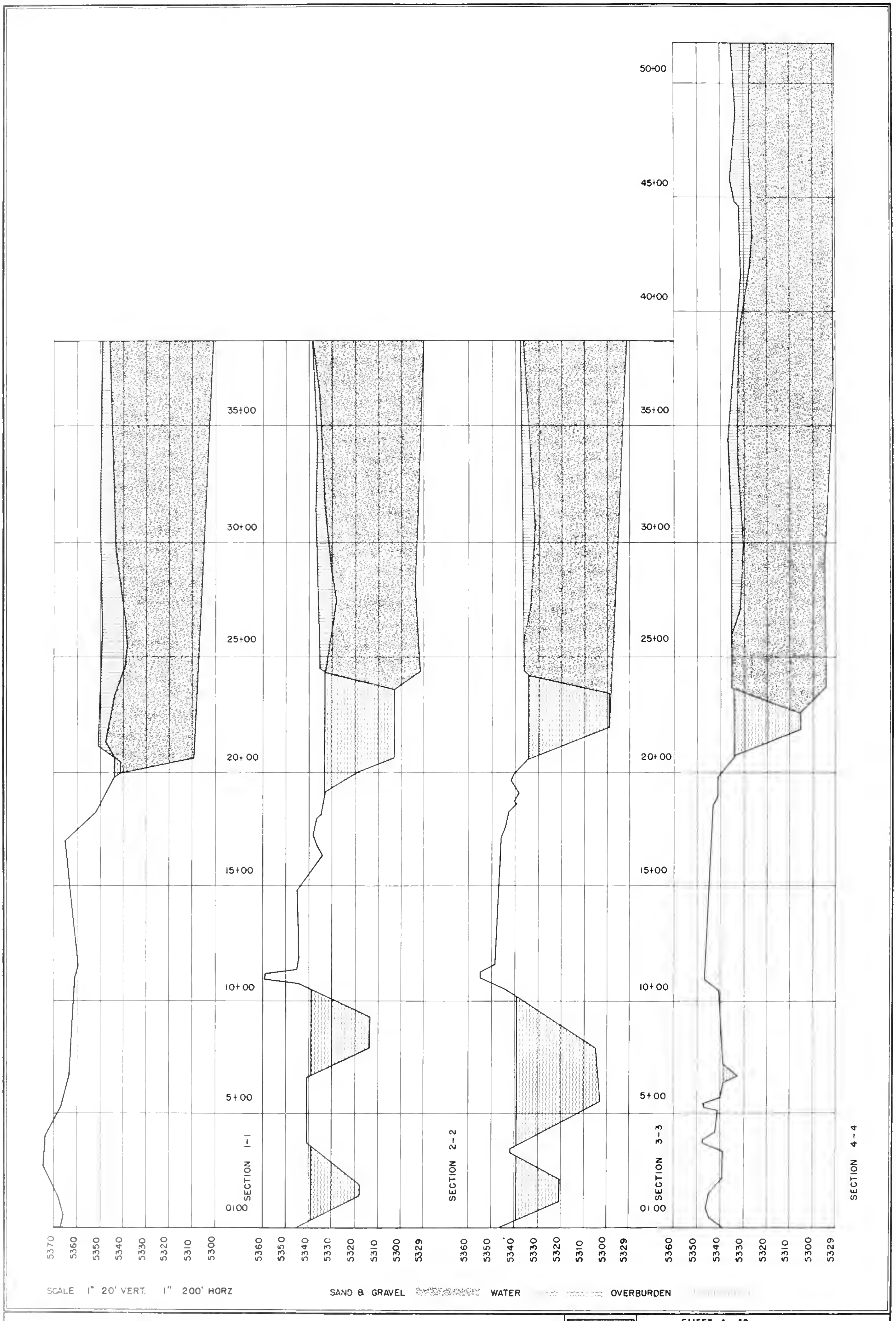

Fig. 62 — Sections

SHEET 4 · 13

SCALE AS NOTED

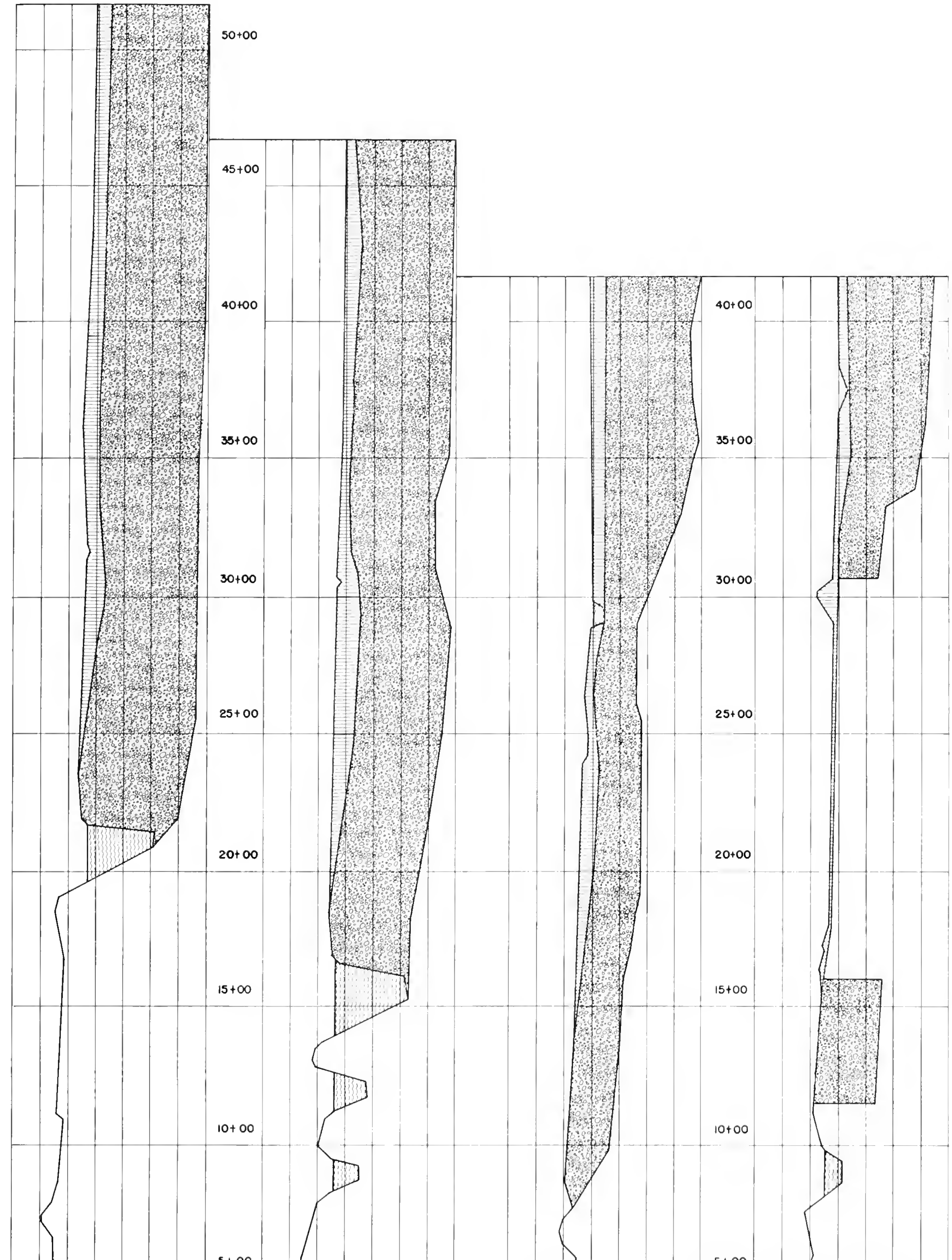

Fig. 63 — Sections

SHEET 5 - 13

SCALE AS NOTED

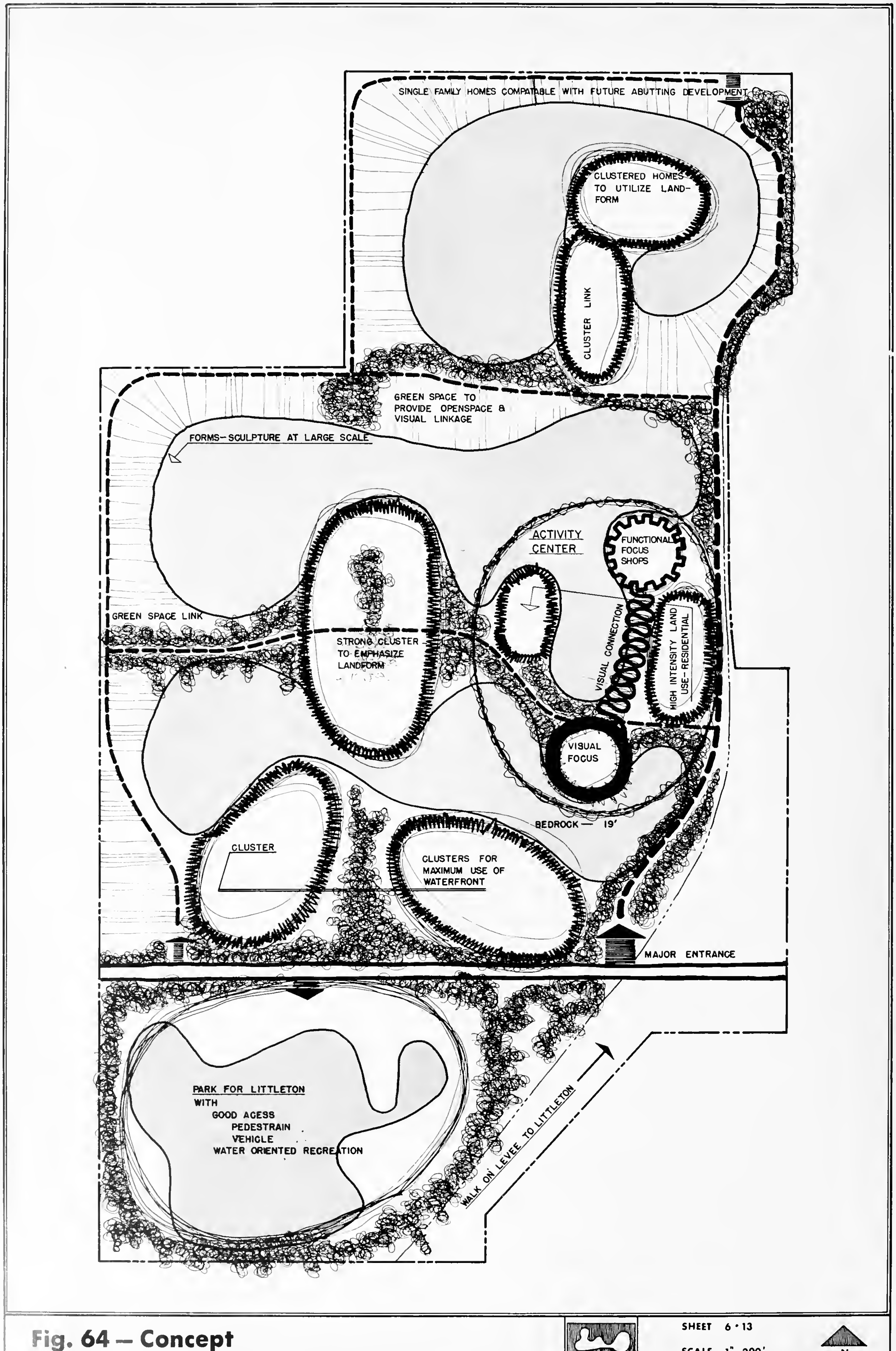

Fig. 64 — Concept

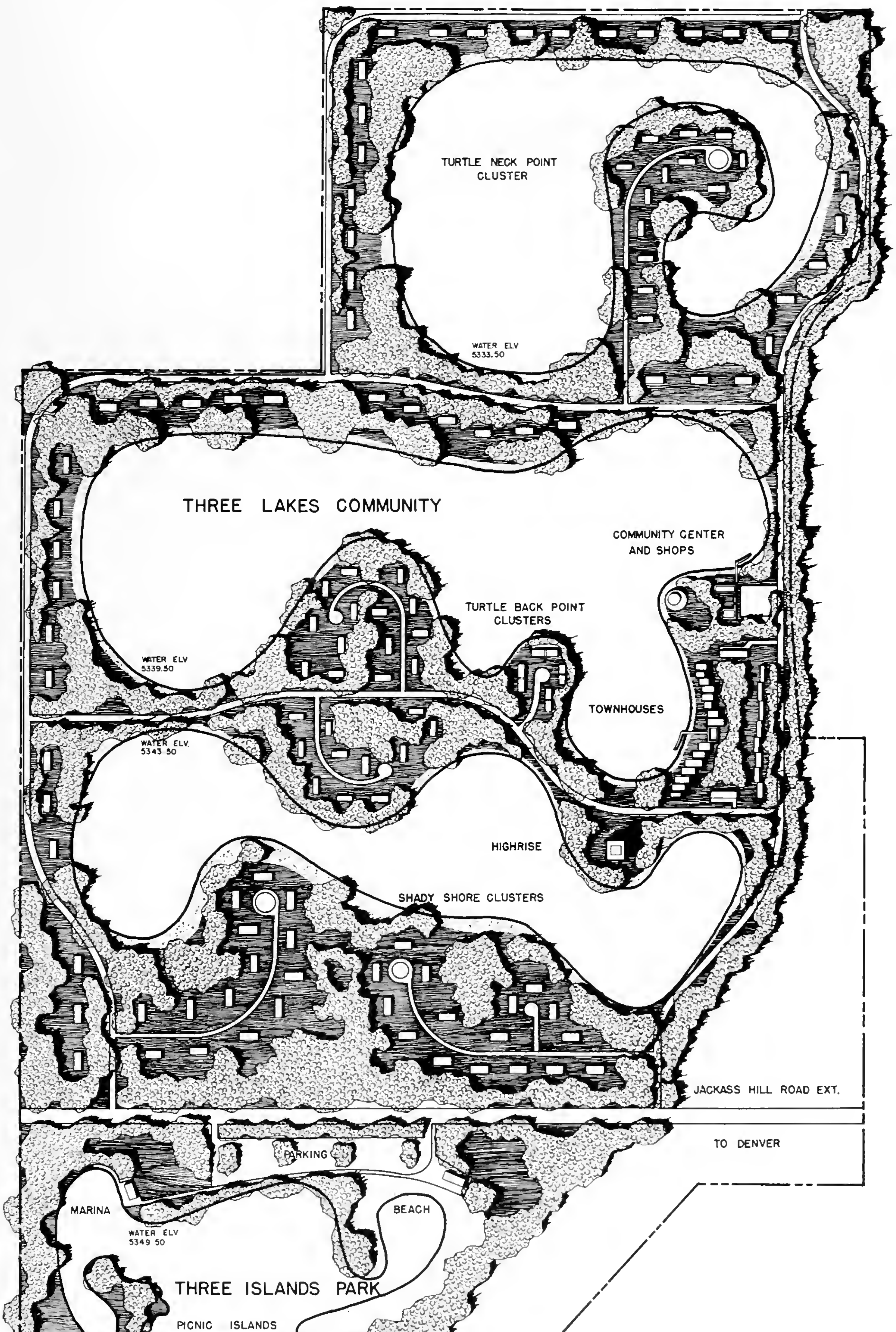

Fig. 65 — Master Plan

SHEET 7 · 13

SCALE 1" - 200'

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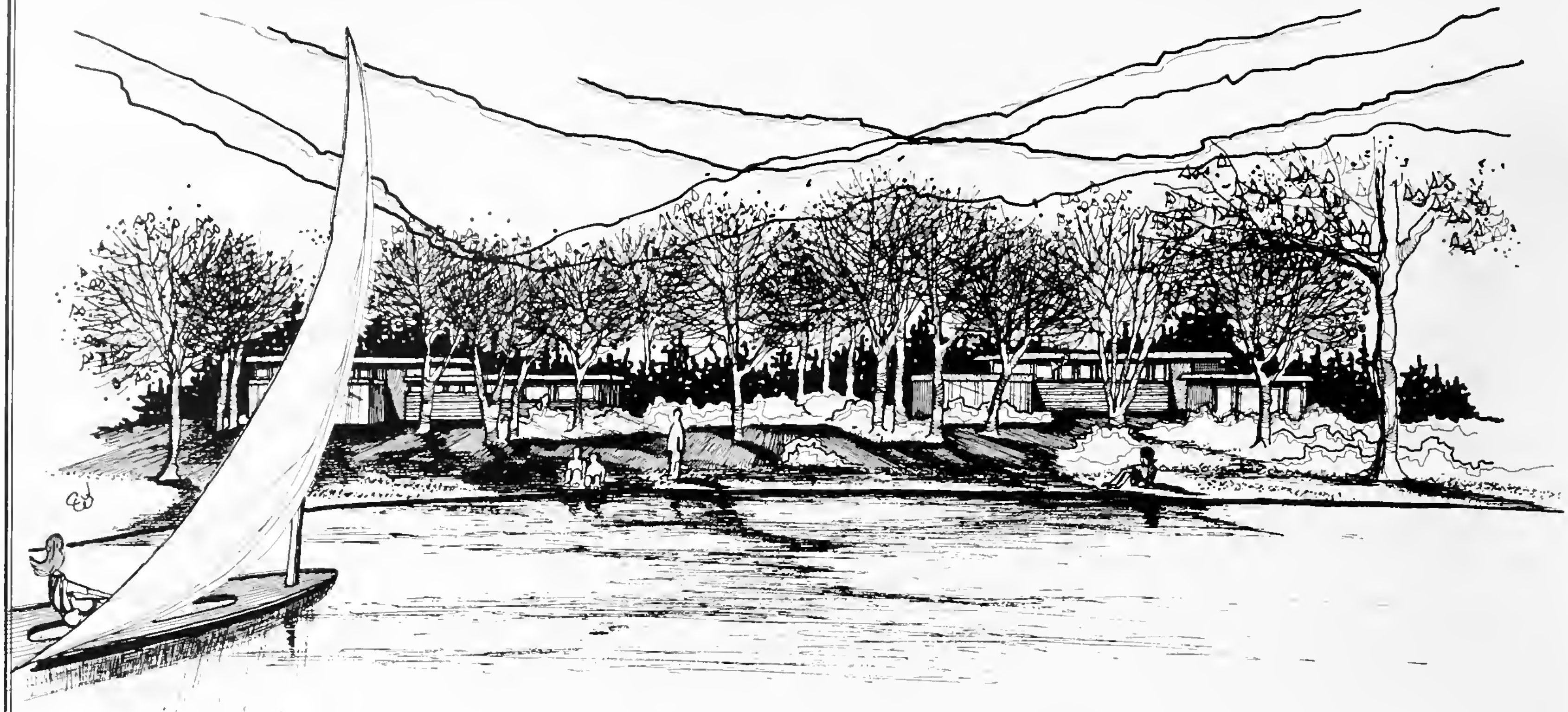
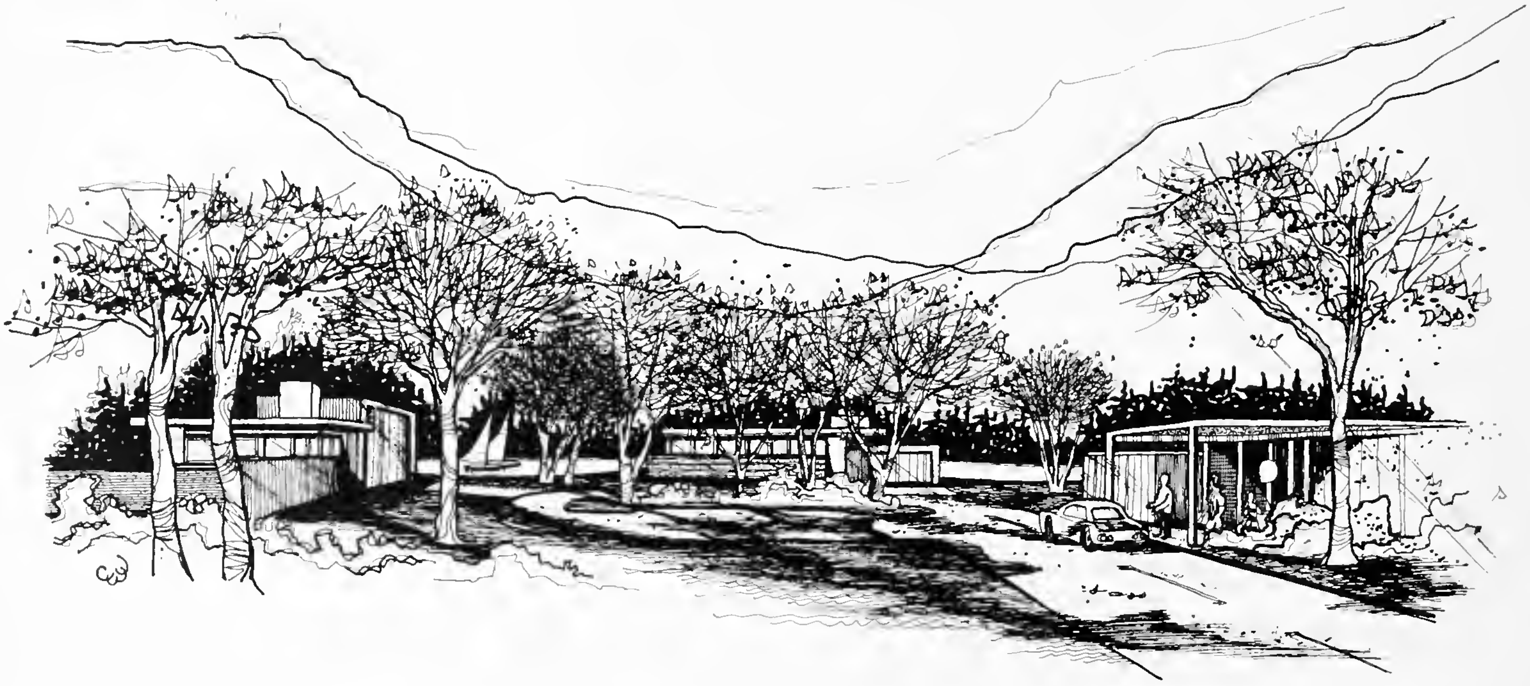


DETACHED HOMES



CLUSTERED HOMES

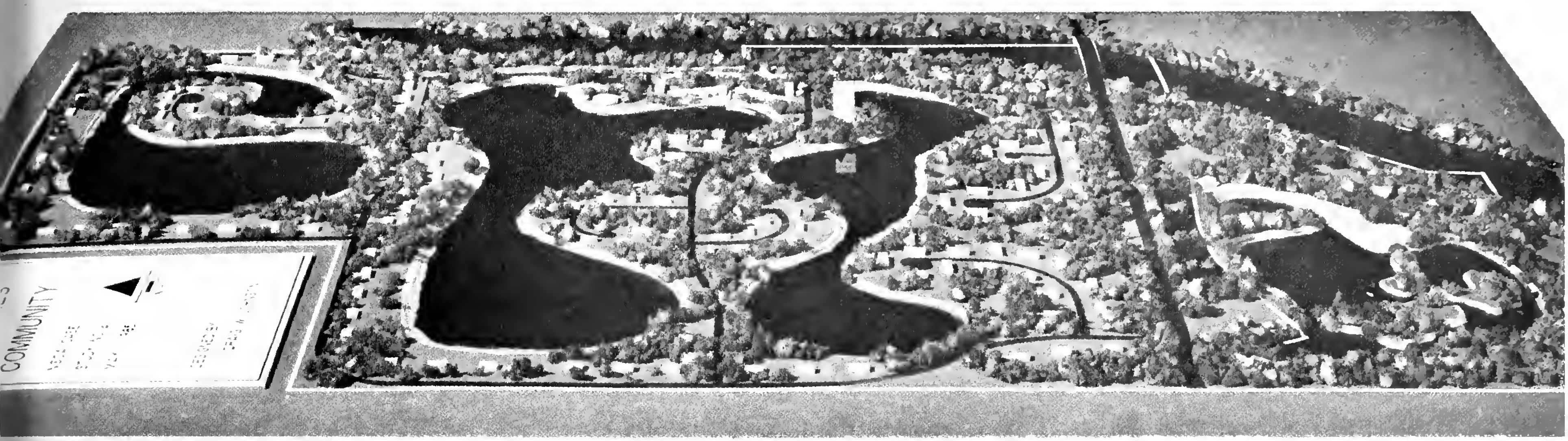
TOWNHOUSES

Fig. 66 — Sketches

SHEET 8 · 13

NO SCALE

N



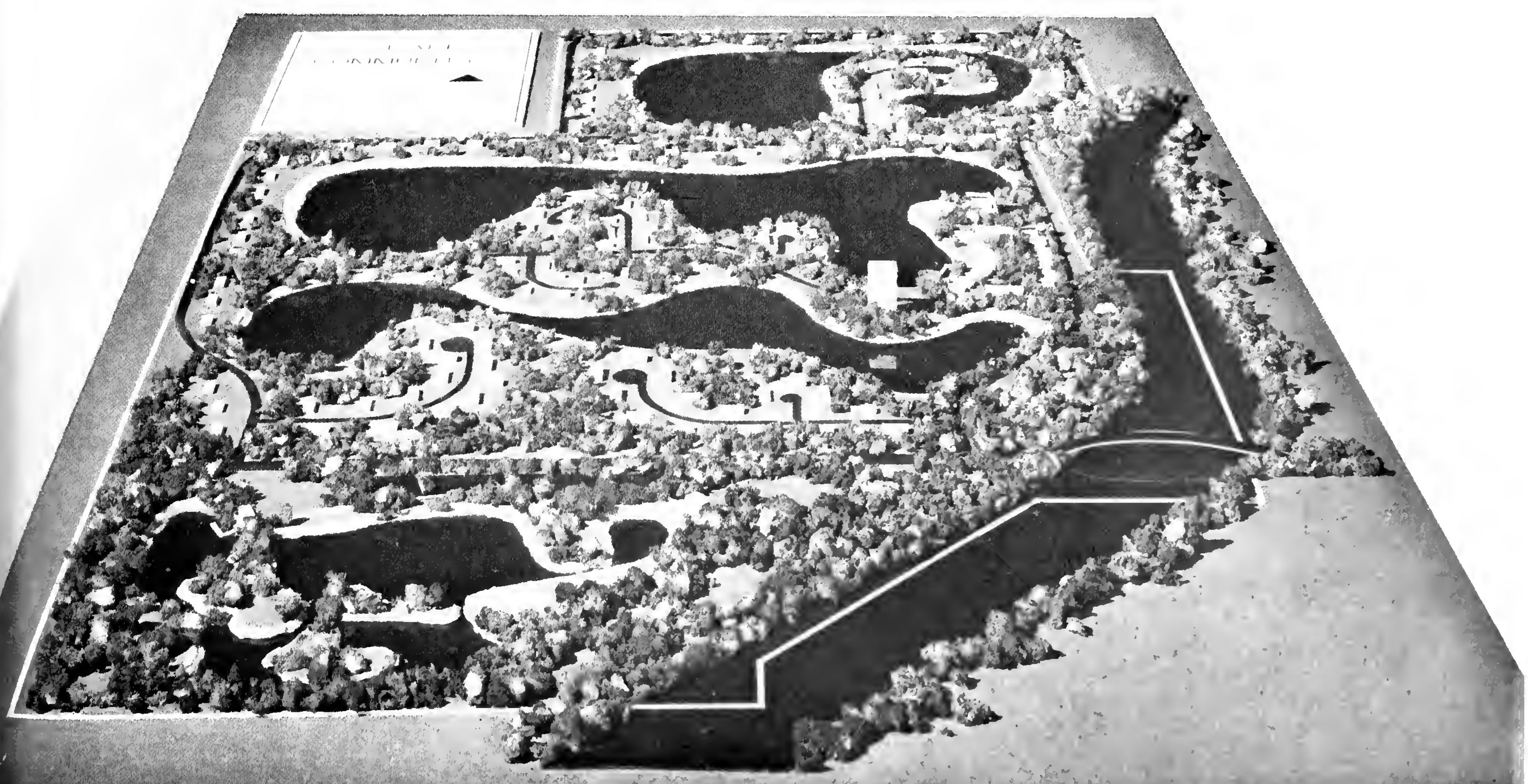


Fig. 67 & 68 — Model

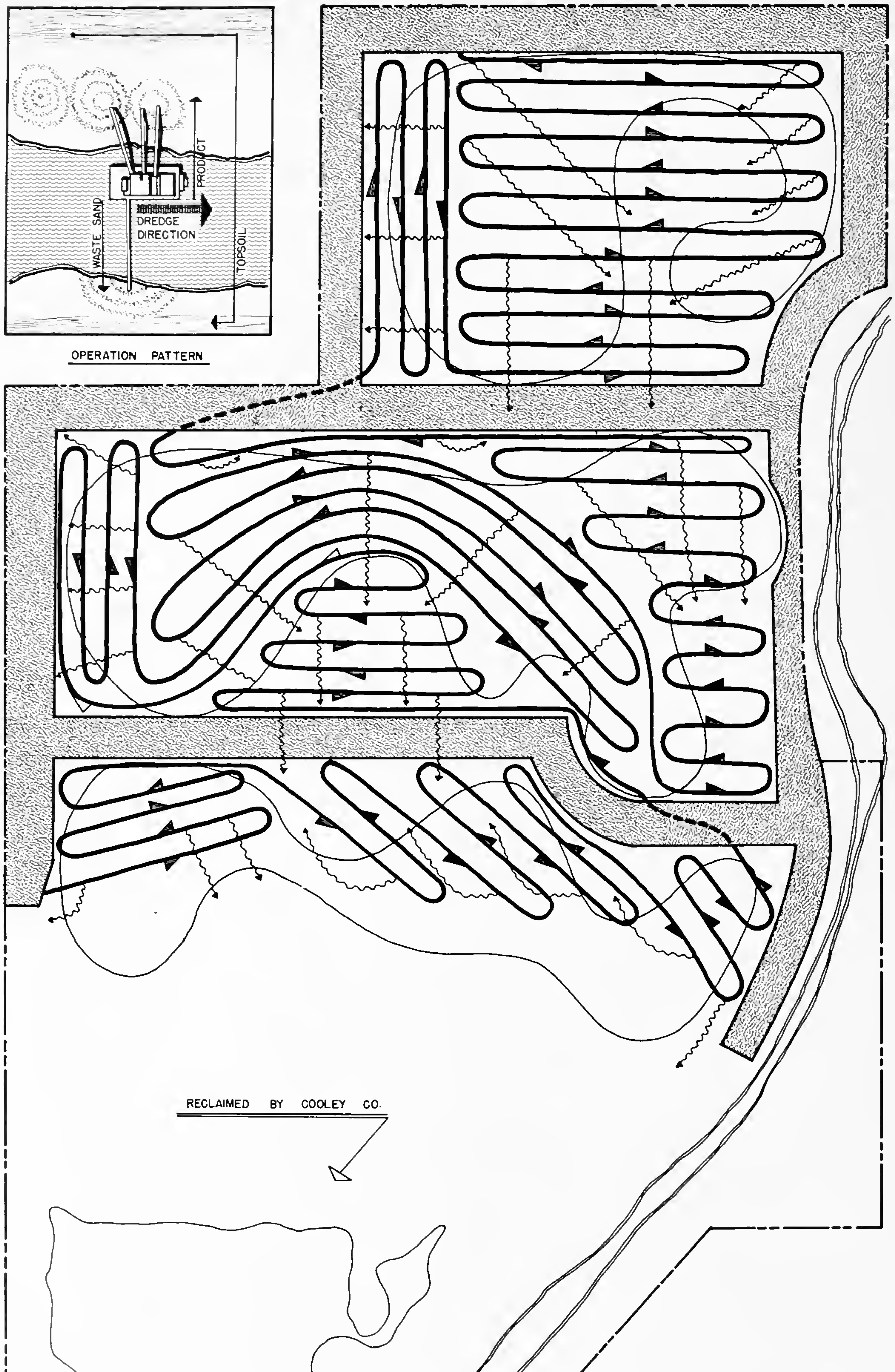


Fig. 69 — Operation Pattern

SHEET 9·13

SCALE 1" 200'

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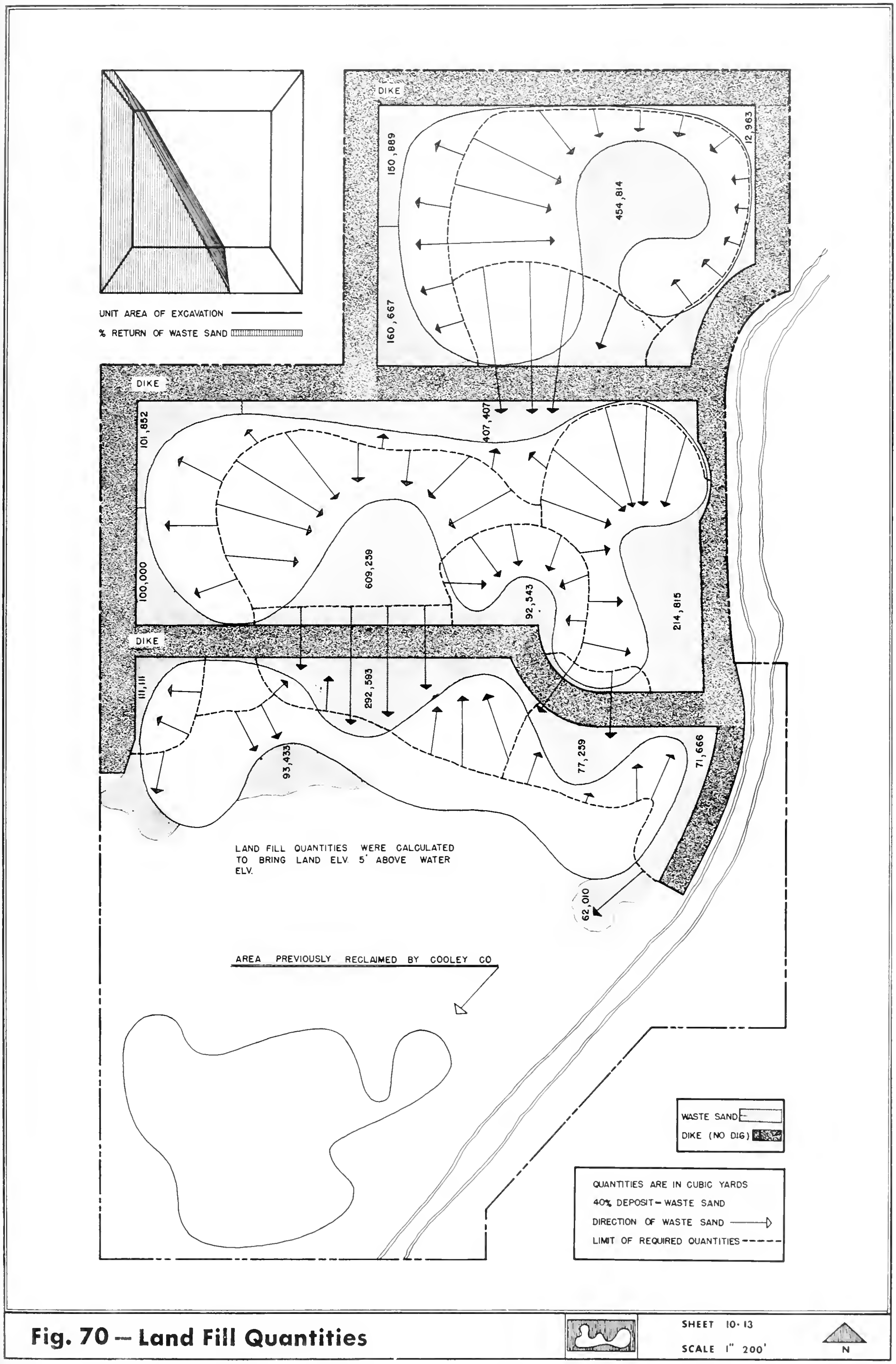

Fig. 70 — Land Fill Quantities

SHEET 10·13

SCALE 1" 200'

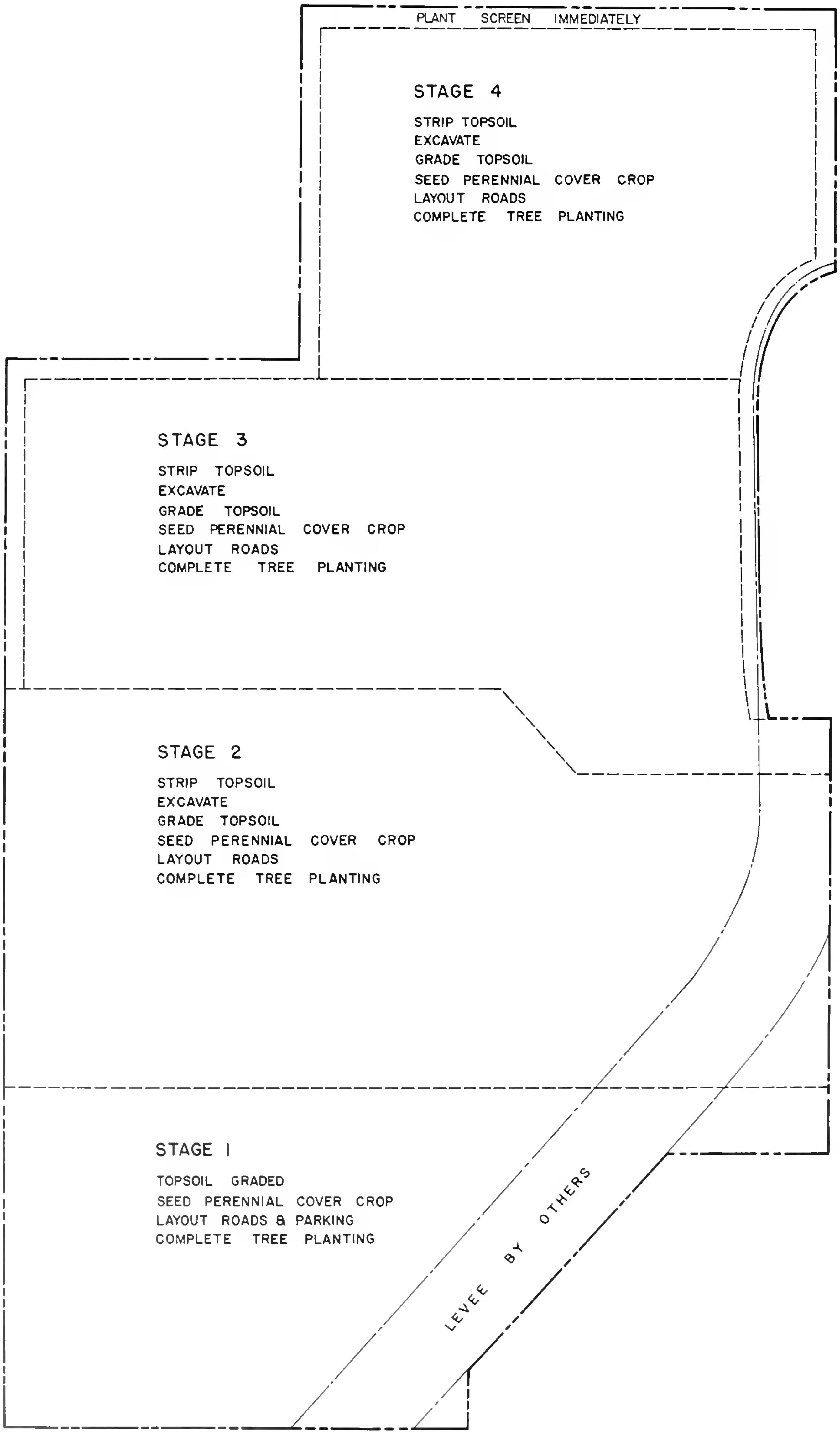

Fig. 71 — Staging

SHEET 13 - 13

SCALE 1" = 200'

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Chapter 4

Conclusions

Introduction

To date, most rehabilitation occurring on sand and gravel sites has been oriented toward fixing up depleted sites. Rehabilitation of this nature has not been completely successful because the expense and effort involved in completely healing the scars of unplanned excavation have been prohibitive.

The dramatic picture portrayed by unrehabilitated or partially rehabilitated sand and gravel sites has been a severe handicap to the sand and gravel industry. Many communities have adopted zoning regulations to curtail operations and have refused to issue excavation permits in an effort to keep out surface mining. As a result, other types of development have occurred on the potential excavation sites, covering thousands of cubic yards of sand and gravel annually beneath a mat of concrete and asphalt.

In the face of a mushrooming population and the subsequent increase in demand for sand and gravel products and land for all types of public and private development, the sand and gravel industry must perform a dual function. It must continue to produce quality sand and gravel products and develop its sites progressively into land areas that can be adapted to a variety of uses on completion of excavation.

Planning

Simultaneously planning excavation operations and site development, prior to excavation, is the most efficient way to perform the dual role of resource extraction and land rehabilitation. Planning should include an inventory and analysis of:

1. site
2. deposit
3. cultural features
4. equipment
5. operations

The benefits of planning, related specifically to the application of equipment and operations for site development, are many.

1. Site analysis including cultural features will reveal specific site features that should be preserved or altered by proper operation planning and the use of equipment. It may also in-

dicate portions of the site that will require screening or other such features to reduce operation nuisance problems so that excavation can proceed in the least objectionable manner possible.

2. A graphic analysis of deposit characteristics will illustrate the topographic character of the site after excavation and the quantities of material available for various land development uses. This information will suggest what operational steps and use of equipment will be necessary to achieve the desired ultimate site form.

3. The inventory and analysis of equipment and operations will point out the potentials of each item of equipment and operation for site development. Once these potentials are known, they can be exploited during the course of normal operating procedures and organized with a time and motion diagram to maximize site development and minimize time, effort, and interference with production.

Most of the detailed plans will be completed during and after the excavation to adjust alignments, land forms, and elevations to fit in with unexpected deposit variations. In addition, due to the long life of many deposits, environmental changes may require alterations of the detailed plans. Master plans are not absolute in the sense that final elevations shall be within a few inches or that the land forms shall be in the exact area and form proposed.

Equipment, Operations and Recommendations

The following discussion is a generalized summary of operations results, and recommended procedures to capitalize upon equipment potential for site development.

Clearing

1. Clearing of necessity removes the vegetation from the excavation area and produces the first visually significant impact of operations.

2. Clearing equipment, primarily dozers and loaders, can be used for a variety of clearing associated rehabilitation procedures including:

A. Selectively clearing only those trees within the excavation area and avoiding damage or injury to plants that are to be conserved.

B. Moving and transplanting small trees and shrubs from the clearing area to the site periphery.

3. Clearing operations can be improved to avoid waste disposal of timber.

4. Planting of trees, shrubs, and grasses is recommended for screening in areas that will not be cleared or excavated.

Stripping, Stockpiling, Excavating

Stripping and stockpiling operations remove the various layers of overburden that cover the deposit, and excavation operations remove the sand and gravel usually to its natural depth limitation. The land forms that result from these operations are affected by deposit depth, quantity of overburden, and the type of excavating equipment. Commonly created land forms include:

1. slopes of varying heights and gradients
2. basegrade topography in a variety of topographic configurations
3. water areas of varying depths and sizes.

A site may contain one, all or a combination of these various land and water features.

The topographic characteristic of these various land and water forms becomes areas of concern for rehabilitation because the proposed land use for the site must be fitted into the topography and this wedding of site and land use can occur and should be accomplished in the most economical and esthetically pleasing manner possible.

Thus, one of the primary objectives of rehabilitation planning is to excavate the site so that its topography can be readily and economically inhabited by the proposed land use and will drain properly to protect development. A grading plan should be adopted as a guide to excavation for achieving the above mentioned objectives. The plan should set the basegrades and slope grades and the gradients of drainage ways. It should be precise enough to meet the requirements of the proposed land use. Generally, less accurate grading is required for extensive types of land uses such as parks and wildlife preserves.

Equipment and operations should be organized into a progressive rehabilitation cycle which can be an integral part of extractive operations. The rehabilitation cycle consists of the following steps.

1. Staged stripping of overburden
2. Excavating to the predetermined elevations set by drainage and land use requirements.
3. Replacement of overburden and topsoil upon the previously excavated areas to meet the finished grade requirements specified in the grading plan.

Equipment commonly used for excavation of dry sites includes draglines, shovels, clamshells, scrapers, and cable excavators. Of these, the dragline and scraper are used extensively for stripping and stockpiling operations as well as excavation. All these types of equipment or combinations of equipment are capable of utilizing the rehabilitation cycle. The only difference is in the specific details of procedure required to fit the various operating patterns of equipment.

The application of equipment for rehabilitation is primarily oriented to creatively developing the site, its slopes, and its basegrade topography into usable portions of the site and has produced the following suggestions:

Screening

Scraper

1. Creation of interesting screening mounds by the deposit of overburden in interesting patterns.

Dragline, Dozers

1. Dragline used to deposit stockpile mounds along the site periphery and the dozer is used to shape the piles into interesting forms.

Slope Development

The objective of slope development is to create slopes that are stable, safe, and if possible usable parts of the site. Equipment can be used in the following manner to achieve these objectives.

Dragline

1. Controlled excavation to achieve the desired gradient.
2. Inclined stockpiling to fill out the slope.
3. Terracing.
4. Backsloping.

Scrapers

1. Controlled excavation to achieve the desired gradient.
2. Filling out the slope with overburden from the pit floor upward.
3. Terracing.

Shovels, Clamshells, Cable Excavators

1. Controlled excavation to achieve the desired gradient.
2. Terracing.
3. Combining excavation operations with overburden disposal using trucks or scrapers to fill out the slope from the pit floor upward.

Dozers

1. Cutting back the steep slope and covering it with overburden.
2. Terracing.
3. Assisting in all the above mentioned techniques for slope development.

Trucks

1. Dumping overburden from above previously excavated slope until the desired gradient is reached.
2. Filling out the slope from the pit floor upward.

Basegrade Preparation

The objectives of basegrade preparation are to prepare the

pit or hillside floor so that it drains properly and can be utilized by the predetermined land use.

Dragline

1. Controlled excavation and controlled stockpiling in the previously excavated areas.
   A. Regrading of stockpiles by dozers where stockpiles are small.
   B. Dual row stockpiling and regrading by dozers or scrapers where stockpiles are large.

Scrapers

1. Controlled excavation and in place deposition of overburden over previously excavated areas.

Shovels, Clamshells, and Cable Excavators

1. Controlled excavation and replacement of overburden over previously excavated areas by whatever type of stripping precedes excavation.

Dozers and Graders

1. Regrading and shaping of basegrade, overburden, and topsoil.
2. Development of special site features.

Trucks

1. Used in combination with boom and cable type excavators to transport and deposit overburden in desired areas.

Water Areas

The objectives of wet site development in most cases is to develop water areas that are deep, have large areas of open water and are clean. Water area development may also include land forming and diking which is a technique to use to increase the number of buildable sites near the water. Equipment commonly used for wet site excavation includes draglines, dredges, clamshells, and cable excavators. Of these only the dragline is used extensively for stripping and stockpiling; scrapers may be called upon to strip and stockpile the overburden.

Dragline

1. Excavating in various patterns which will consolidate overburden windrows and create open water areas.
2. Double casting overburden to create larger water areas.
3. Removal of "no dig" areas from water.
4. Shaping of shore lines.
5. Dike construction.

Scrapers

1. Stockpiling overburden where it can be used for landscaping.
2. Dike Construction.

Clamshells and Cable Excavators

1. Controlled excavation to achieve the desired water depth.
2. Combined operations with stripping equipment for land forming and diking.

Dozers and Trucks

1. Assist in dike construction and land forming.

Processing and Transporting

The processing plant, storage area, and related surge piles of unrefined material are the imageable features of a sand and gravel operation. The immediate processing plant area is the primary generator of noise and dust problems and the primary tool offered for the planned disposal of waste sand.

Proposals

1. Processing plants which are equipped with a desander have an excellent potential for land forming. Several factors are important in utilizing the desander for this purpose.
   A. Waste sand deposit areas should be located where they will be most beneficial to site development. Such locations would include:

Fill in shallow water areas	Areas for beach development
Fill for low dry land areas	Shoreline development
Landforming of various types	

   B. Waste sand used for land forming should be pumped behind or into container dikes or check dams so that the maximum use of waste sand for fill material will be realized. Since overburden is an unprocessable material common to most sites, it is recommended that it be used for dike construction on wet sites. Wood and corrugated metal may also be used for diking purposes.
   C. Areas filled with waste sand should be covered with overburden and topsoil to provide a base for vegetation.
2. Noise and dust problems should be eliminated at the source when possible.
3. A location for the processing plant should be selected that is easily accessible to circulation routes, yet is as unobjectionable as possible.
4. Screening with overburden, surge piles and vegetation should be used to further dissipate noise and dust problems. The screening elements should be organized in an interesting manner to form a composition that will project an interesting and dynamic compatible image of the operation.

Benefits

Development of the optimum land use and reduction of normal objectionable operating conditions can best be achieved by adopting a plan prior to an excavation and implementing it during the execution of operations. The plan must capitalize upon natural site assets and utilize equipment and operating potential as they become available throughout the duration of operations, if it is to be implemented economically. A responsible predetermined land development program will contribute to the welfare of the producer, the community and the country in four ways:

1. Development plans drawn up prior to excavation will not impede the producer's efforts to supply a growing demand for sand and gravel products.

2. A demonstration of responsible land development practices on the part of the producer will improve his public image.

3. The development of a depleted site will not plague the community with what may have been an ugly scar upon its landscape complexion. Instead, rehabilitation can create landforms that are usable for a variety of public and/or private functions.

4. The developed site will likely present the producer with a real economic gain as valuable real estate for resale upon the completion of operations.

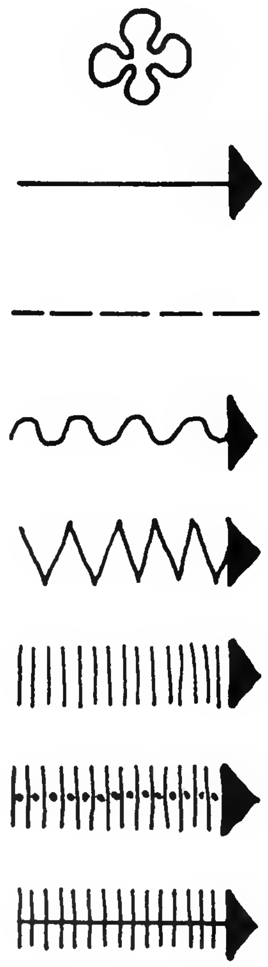
Future Research

Future research will be devoted to ultimate land use and public relations. The major objectives shall be to identify the characteristics and potential of typical site features resulting from sand and gravel operations, to determine typical site requirements for various potential land uses and to demonstrate how the finding may be applied in the planning procedure for ultimate use of sand and gravel sites. Public relations problems of operating and abandoned sand and gravel sites and demonstrations of how site planning techniques may be effectively utilized to alleviate objectionable site conditions will be introduced with examples of suggested solutions.

A thing is right only when it tends to preserve the integrity, stability and beauty of the community; and the community includes soil, water, fauna and flora, as well as the people. — Aldo Leopold

APPENDIX

This appendix is an inventory and analysis of equipment commonly used in sand and gravel operations. The purpose is to orient the layman and the planner-designer, unfamiliar with the sand and gravel industry, to the working capabilities and limitations of the equipment used in excavation, their normal operating patterns, and typical land form results.



Processing Plant

Direction of Excavation

Return

Direction of Stockpiling

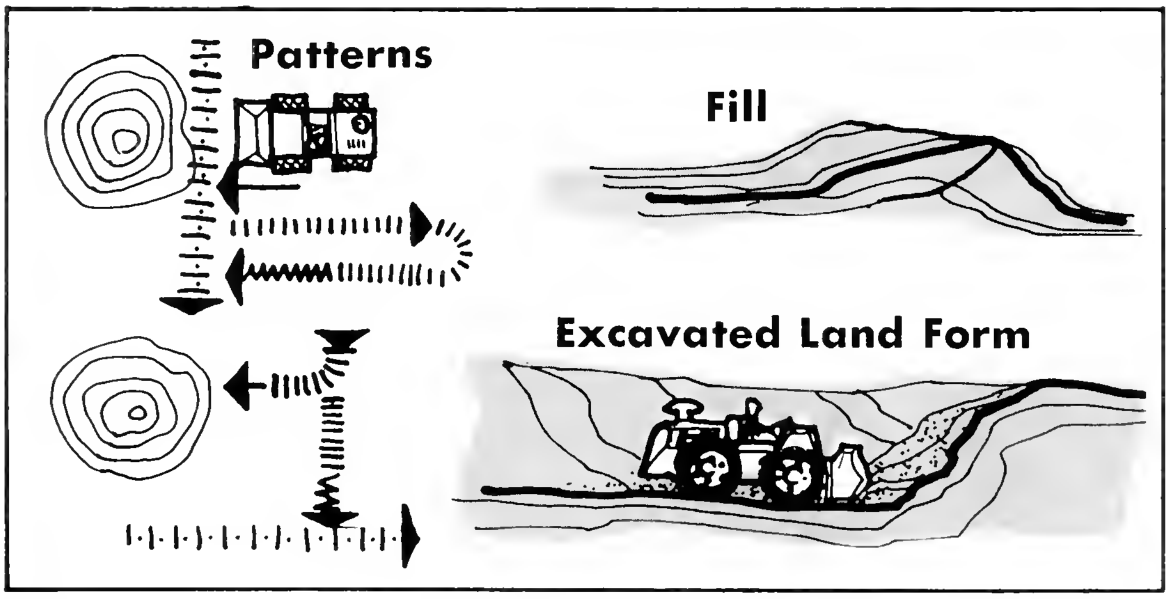
Dump

Self Transportation

Transportation by Other Vehicles

Pipeline Transportation

LOADER

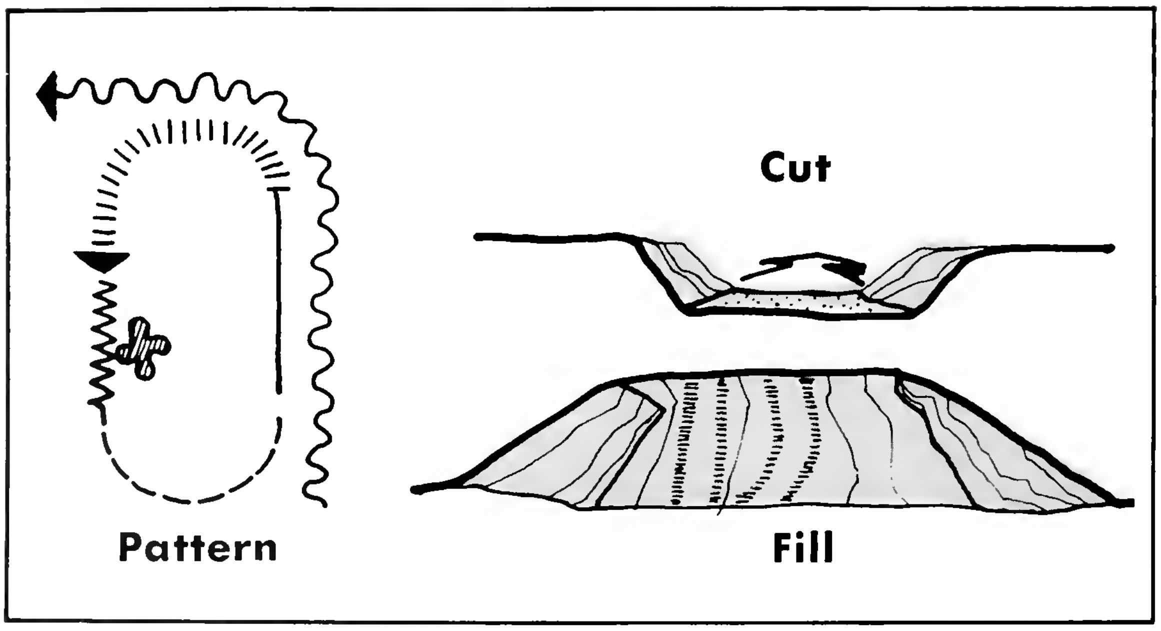


Loaders are the most recent addition to the sand and gravel producer's line of equipment. They were designed by heavy equipment manufacturers to provide the earth moving industry with a fast, maneuverable item of equipment capable of loading loose material in a short time, and being able to move from one working site to another rapidly under its own power.

There are several different types of loaders, but the two-wheel and four-wheel drive front end loaders are the most common in the sand and gravel industry. They feature bucket capacities up to six cubic yards. They are moved along at speeds up to 30 mph by 200 to 500 horsepower motors. The turning radius for most models is about twenty feet, making loaders very flexible and capable of working in tight quarters. Loader operations are only nominally affected by grades because the normal loading cycle distance is usually less than fifty feet.

Most loaders are used in sand and gravel operations for loading trucks at the excavation site and the processing plant. In a limited number of cases they may be used where the sand and gravel deposit crumbles easily to the pit floor and can be scooped up by the loader. Loaders are also handy pieces of equipment for clean-up work and diverse detailed tasks, such as feeding the main intake hopper at the processing plant.

SCRAPER



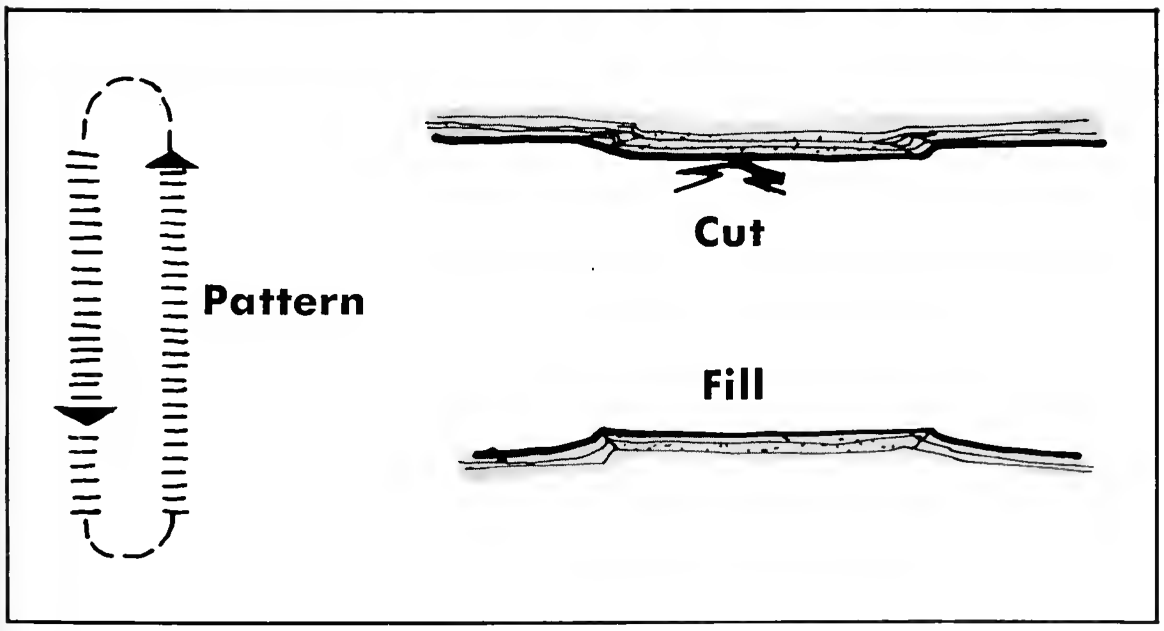
Hailed by many as the most important innovation in the earth moving industry, the scraper is gaining wider acceptance by the sand and gravel industry because of its speed, mobility and hauling capacity. Its biggest advantage is its ability to dig, haul and spread the material all in one motion. It operates on the same principle as the Fresno bucket; but that's where the similarity ends. Modern scrapers can load 17 yards of material and deposit them at high speeds up to fifteen mph requiring less than twenty seconds to empty the pan. They are moved by powerful engines up to 450 horsepower which can move an empty pan 30mph on the return phase of the hauling cycle.

The four basic types of scrapers include: the two-wheel over-hung scraper, four-wheel scraper, twin engine scraper and the crawler-drawn scraper. Each special piece has its own operational advantages. The four-wheeled scraper is most efficient over short hauls, 1,500 feet, and with the overhung cab, it is capable of turning 90° corners with ease. The turning radius when operating at speed is about 25 feet for most models. The twin-engined scraper has two synchronized engines, one in front and one behind the pan. The power generated by these two motors eliminates the need for a pusher dozer. Twin engined scrapers are frequently used where heavy stripping or excavating is encountered. However, the two motors greatly increase equipment weight and reduce the efficient hauling distance to less than 1,500 feet. The slowest of all scrapers, but very maneuverable, is the crawler drawn type with a working speed of five to ten mph. It is very efficient in heavy stripping because of the increased traction offered by the crawlers.

Scrapers are sensitive to both grade changes and weather conditions. The grade resistance in terms of percent of gross vehicle weight is the same as the percent of grade, thus reducing efficiency proportionately. From reviewing job reports it is evident that scrapers have the highest lost-time record due to rain and bad weather.

In a sand and gravel operation, scrapers are used for stripping, stockpiling and excavation purposes. They are used mainly for dry operations or for excavating above the water table on wet sites and regions where the overburden and deposits are free-flowed and contain few large boulders.

GRADER



The early graders were horse-drawn, hand-operated pieces of equipment. Modern graders are powered by 200 horsepower motors with operating speeds of twenty mph. The pitch and angle of the grader blade is hydraulically controlled. For most models the minimum inside turning radius is 35 feet with an average blade length of twenty feet which can be moved off center if desired. Graders or road patrols, as they are called, are used principally for finishing and shaping rather than digging or transporting.

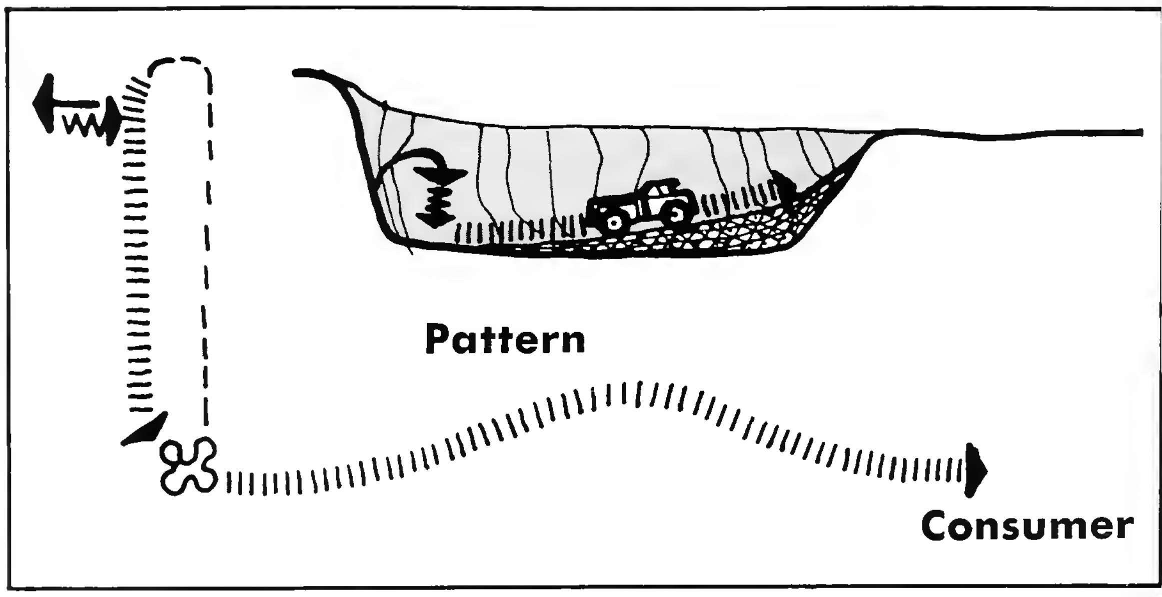
The most common type of grader is the single piece unit; but where rough grading in small areas is required, there are grader blade attachments for trucks and tractors.

Graders can work effectively over unlimited linear distances as illustrated by grading operations in large road projects. They reach the peak of their efficiency curve when operating in this manner and any additional turning or jockeying around will lower output. Graders have the potential to negotiate fifteen percent straight grades and can work 1:1 side slopes when winched over an edge by bulldozers. However, because of their high center of gravity, graders are not efficient at working side slopes over twenty percent when unassisted by other equipment.

Because of their specialized design for finished work, graders are limited in the number of functions they can perform. Scarifiers, rippers and dozer blades are a few attachments that increase versatility.

Graders are not commonly used in conjunction with sand and gravel operations; but on sites where they are utilized, they maintain haul roads, shape stockpiles, provide the finished grading to dress up stockpiles for screening and land forming, and grade topsoil over rehabilitated slopes.

TRUCK



The two basic types of trucks include: 1) the slow, powerful, large-capacity, off-highway vehicles which work within the confines of the site because of their size; and 2) the smaller, faster, conventional road trucks which operate both on and off the site.

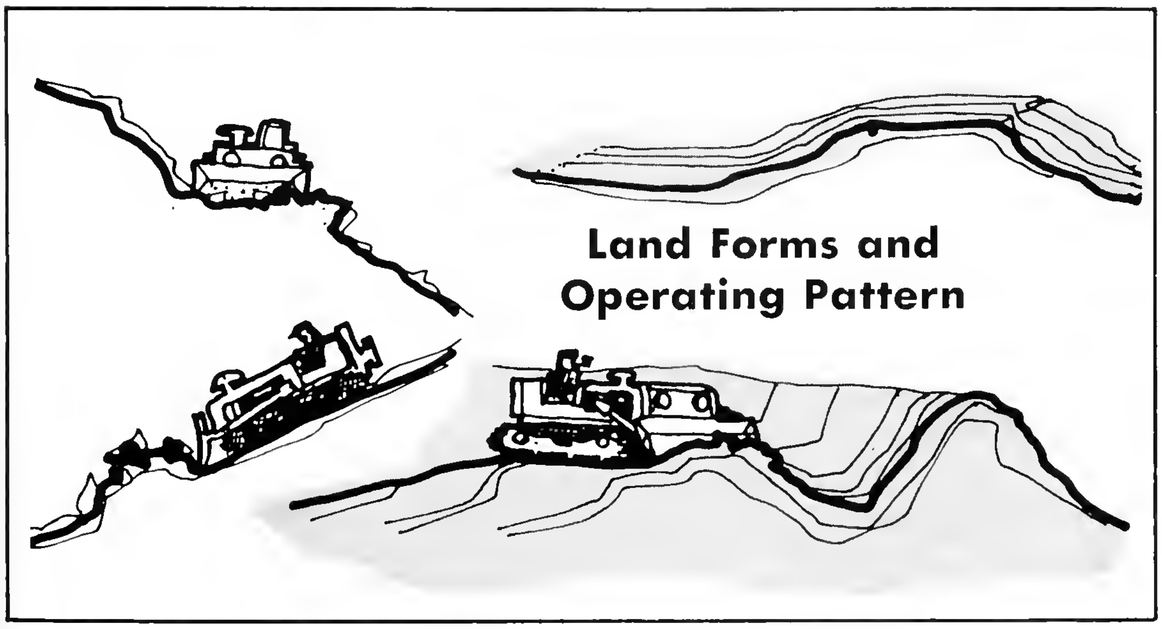
Road trucks have up to 265 horsepower with sixty ton capacity and road speeds of sixty mph. With increased speed and dump capacities, truck evolution has been instrumental in increasing production and distribution rates.

Bottom dump, end dump and side dump are typical types of off-highway trucks. Their capacities of thirty to forty yards are three times as large as conventional trucks. Top speed is usually about 30 mph and inside turning radii for most models is about 30 feet. They are capable of working on 15% or 20% straight grades but once uphill grades exceed 5%, efficiency curves nose dive. End dump trucks are most efficient on steep grades. Bottom dump and side dump trucks exhibit better traction in soft material. Side dumps specialize in building up the edges of fills over long distances because of their large capacity and ability to deposit material off to one side of the cab.

The smaller road trucks have no hauling distance limitations, but the economic pressure of the cost-distance ratio will control haul lengths from the plant to the consumer. Some producers use a fleet of these smaller trucks for work on the site offsetting the large capacities of the off the road vehicles with the faster cycle time of the smaller vehicles. However, their main function is delivering finished products to the customer.

In sand and gravel operations, trucks are used primarily as transporting equipment. Their main function is to transport raw sand and gravel from excavated areas to processing plant and from the plant to the consumer. Trucks may also be combined with draglines or shovels during stripping operations to remove overburden from the excavation area and to deposit it elsewhere.

BULLDOZER



Land Forms and Operating Pattern

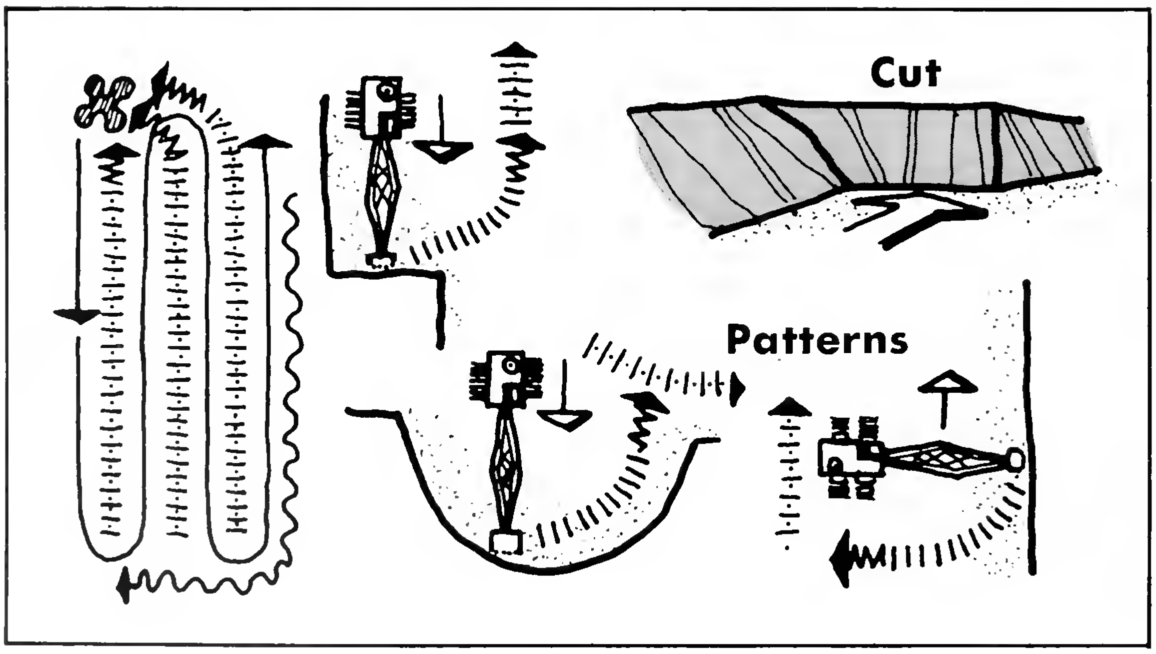
Strength, versatility, and a variety of accessories to handle unique problems make the bulldozer a real workhorse in any sand and gravel operation. Bulldozers, (dozers for short), are the short range member of the family of excavators that dig and transport material to a dumping point.

Dozer sizes range the from 70 horsepower midgets used for small scale detailed work to the 400 horsepower mountain moving giants with working speeds of 6 miles an hour. They can work straight slopes of 45°, but such operations are treacherous in loose material; 30° slopes are considered safe for most soils and weather conditions. The wide track models can work 20° side slopes with ease.

The two basic types of bulldozers are the cable lift dozer and the hydraulic lift dozer. The names denote the method by which the blade is raised or lowered. Both types are very maneuverable and can turn 90° corners within the length of the machine by locking one tread, applying power to the other, and rotating on the locked tread. Except for wet swampy conditions, bulldozers are at home working with any type of soil. Where soils are workable, bulldozers are capable of scraping and spreading material to close tolerances. Tremendous power and slow working speeds are design characteristics of the dozer that limit their efficient operating range to less than 100 feet. Moving earth more than 100 feet is more efficiently done by mobile means of transportation such as scrapers or shovels and trucks. A rule of thumb states that dozer efficiency drops off in a direct ratio with distance.

During the course of sand and gravel operations, bulldozers perform a number of tasks including clearing, stripping over short distances, push loading scrapers, and miscellaneous clean up work around the processing plant. Almost every sand and gravel operation has one or more bulldozers on the site used periodically for one of the above-mentioned tasks. During slack periods when they are not employed in excavational operations, dozers are often used to shape overburden, dress up slopes, or other rehabilitation work.

SHOVEL



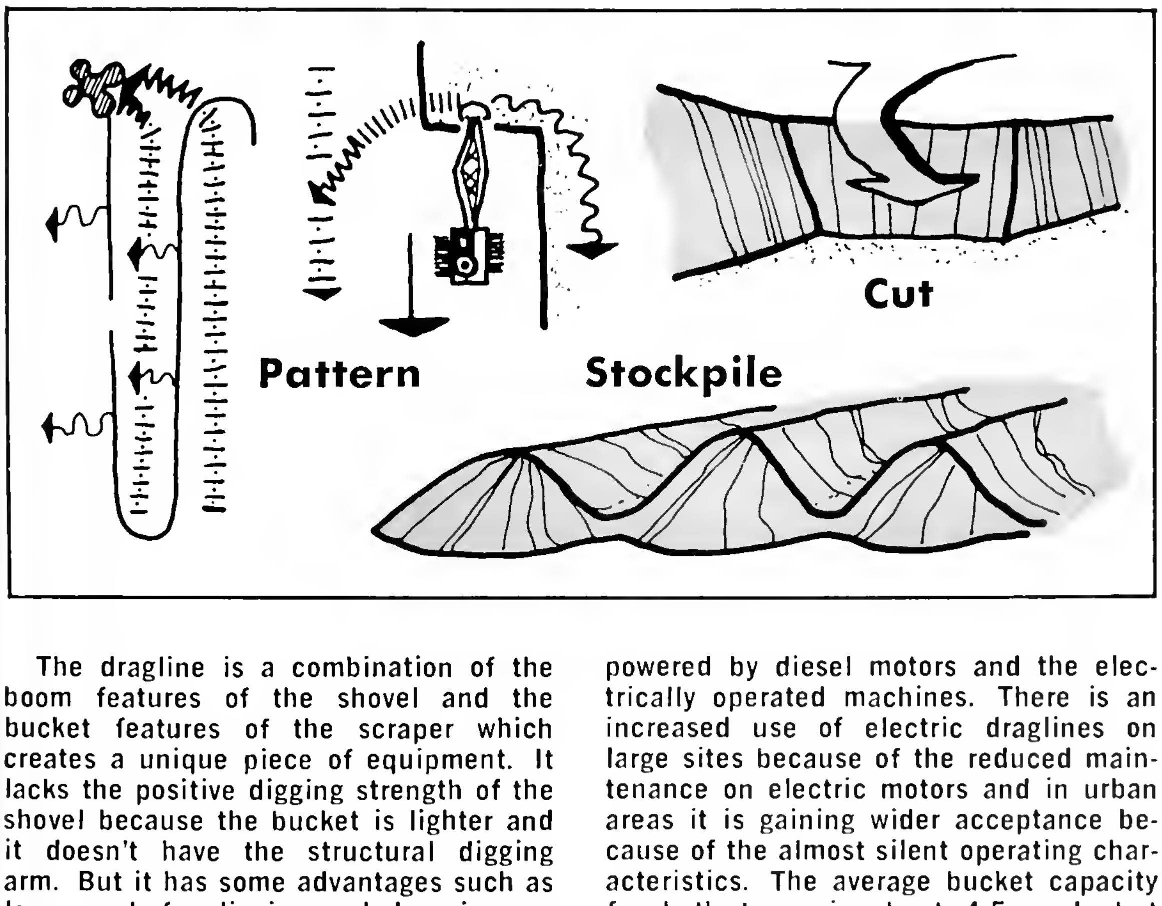
One of the first mechanized pieces of earth moving equipment was the steam-powered shovel. Today they are operated by gas, diesel, and electric power but to most everyone they are still "steam shovels". The principle of shovel operation, a scoop with a trapdoor bottom mounted on an arm connected to a rotating disc, is still the same, but performance standards are much different than those of the methodical monster of yesteryear.

There are still ½ yard buckets like the shovels of old, but standard sizes go up to 14 yards with the average capacity of 4-5 yards. The load, pivot, and dump cycle times are now down to 35 seconds, and are most efficient within arcs of 35-40°. One 14 yard bucket, used in constructing a dam, moved 145,000 yards of material during two, 10 hour shifts. Shovels have a 360° area of operation with an average digging radius of 35 feet. Maneuverability is limited because of the cumbersome boom and the slow movement of the crawler mounted vehicles.

The three most common shovels are the dipper shovel, the crowd shovel, and the pull shovel. Dipper shovels are most efficient at bank excavation and working into a pit wall. They are capable of upcutting 20 feet into a working face and when the height of the pit wall exceeds this dimension the top of the pit is caved in by dozers. The shovel can then pick up the sand and gravel from the pit floor. Both of these shovels are less efficient when required to excavate downward from a surface plane because the mechanical advantage of the leverage arm is reduced. The pull shovel is a more specialized type. It is used for excavating narrow ditches and for straight face excavation from above the pit. The pull shovel is operated by lowering the bucket downward into the pit and scooping the material out by pulling the bucket up against the working face toward the base of the shovel.

Shovels are still one of the most common pieces of equipment in the sand and gravel industry. They are used almost exclusively for bank excavation and loading. They are very efficient at handling a deposit because of large bucket sizes and the leverage power of the digging arm. However, they are strictly a land-based piece of equipment limited to dry operations.

DRAGLINE



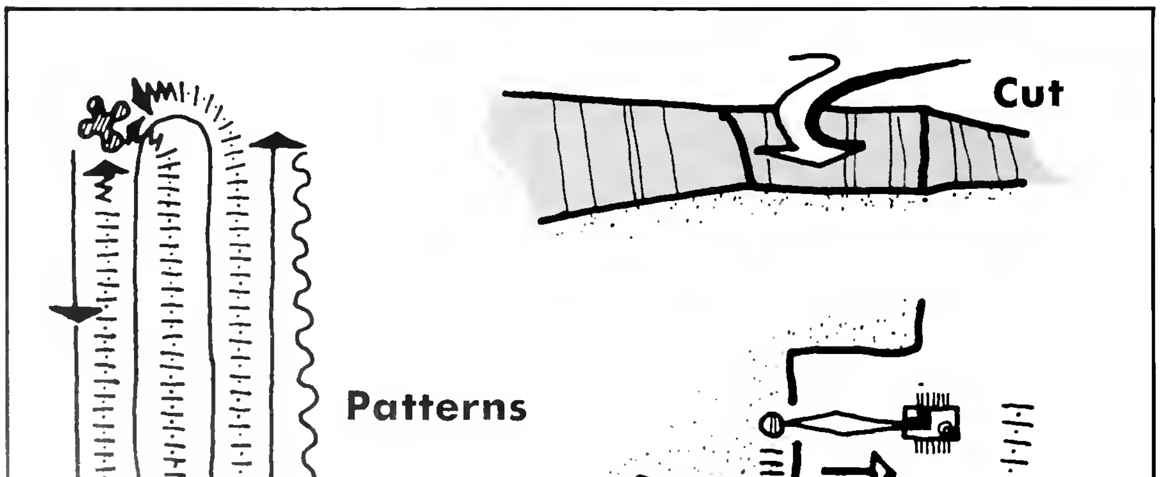
The dragline is a combination of the boom features of the shovel and the bucket features of the scraper which creates a unique piece of equipment. It lacks the positive digging strength of the shovel because the bucket is lighter and it doesn't have the structural digging arm. But it has some advantages such as long reach for digging and dumping, up to 250 feet, because of the lighter, longer boom and a very fast cycle time.

The two most common types are those powered by diesel motors and the electrically operated machines. There is an increased use of electric draglines on large sites because of the reduced maintenance on electric motors and in urban areas it is gaining wider acceptance because of the almost silent operating characteristics. The average bucket capacity for both types is about 4-5 yards but some of the huge models used in large sand and gravel operations and on dam sites may reach 85 yard capacities. Draglines are capable of casting the bucket beyond the radius boom point but most digging is done beneath the boom tip. Boom length and the angle of inclination between the boom and the base plate determine the horizontal distance that a dragline can excavate and dump. If the horizontal distance is increased, a bucket of smaller capacity must be installed or counterweights added to the dragline's cab to keep the dragline balanced and avoid tipping the machine.

A walking dragline is a special adaptation for working large deposits in flat topography. It moves in a fashion similar to a man crouched down with both hands at his sides, palms down on the floor. As he rocks forward his hands hold his body up until his feet touch the ground in front of him and then he moves his hands into position at his sides again to repeat the cycle. This slow cycle is repeated by the walking dragline continuously at the rate of 1/5 of a mile an hour until the destination is reached.

The dragline is one of the most common items of earth moving equipment used in the sand and gravel industry, especially in wet sites, because of the diversity of functions it performs—stripping, stockpiling, and excavating and its fast cycle time for loading trucks and hoppers.

CLAMSHELL

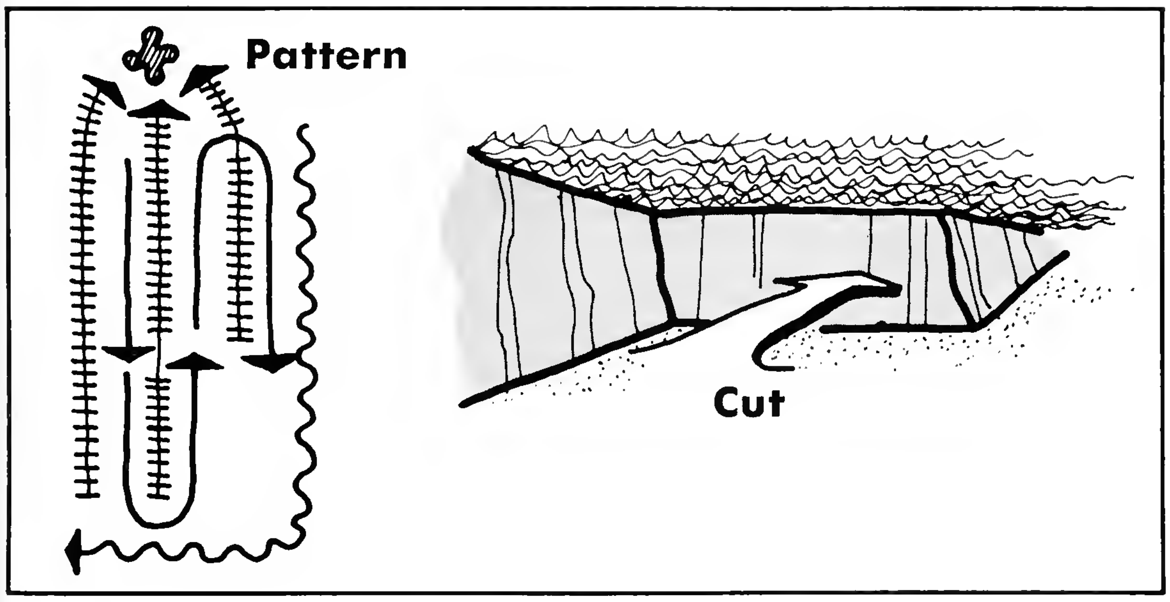


The clamshell is the Jack-of-all-trades in the excavation end of sand and gravel operations, capable of performing all the operations of the dragline and the shovel, but with less efficiency. The clamshell has a slower cycle time than the dragline to allow for the additional step of opening and closing the bucket. Its specialty is digging straight sided pits, working from the top of the pit downward. The depth to which a clamshell can excavate is limited only by the height of the boom and the cable capacity of the uptake drum.

Bucket capacities vary from 1/2 to 8 yards and operate much like the "diggers" at the penny arcade. The bucket is dropped with the mouth open into the deposit. The operator loads the bucket by closing it with a biting action and the load is raised from the pit floor to be loaded into trucks or hoppers. The crawler mounted clamshell is slow-moving and maneuverability is limited because of the long boom and slow speed of crawler mounted models.

The clamshell is at home in both wet and dry operations. With a heavy bucket, it is capable of digging in any type of material except solid rock, and is used mainly for excavation in sand and gravel operations.

DREDGE



The dredge is a naval extension of sand and gravel operations. It is used for the excavation of large river deposits and on large inland wet operations. Some dredges have incorporated the processing plant on board, such as one rig in the Denver area which has the whole operation shipside, with the exception of the office and weighing station.

The two basic types, the hydraulic dredge and the ladder and bucket, have been hybridized with accessories and modified by producers to meet various operational problems. Both types are powered by either diesel or electric power for dredges operating in urban areas because the silent operation is less disturbing to surrounding land users.

The ladder and bucket dredge is not as common as the hydraulic dredge, but it is frequently used on sand and gravel sites. It operates on a principle similar to the water wheel—a continuous cycle of buckets that dig into the deposit, load, dump onto the dredge and return to dig again.

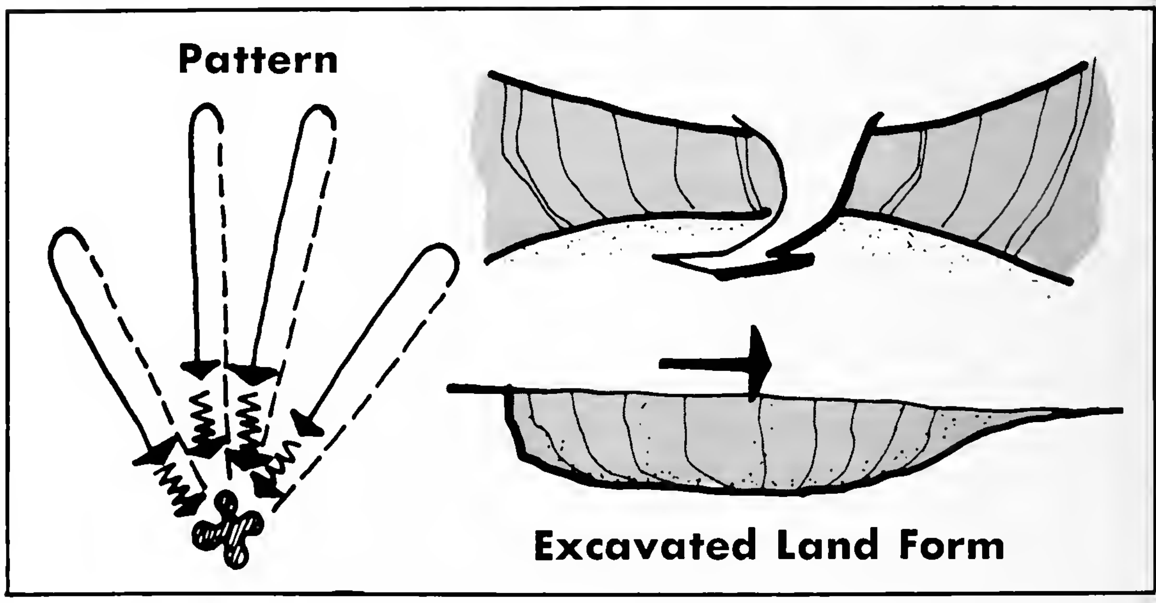
The hydraulic dredge works on the same principle as the vacuum cleaner and is used commonly on inland wet pit operations. It consists of floating vacuum pumps which suck in sand, gravel and water and deliver them to the processing plant.

Ordinarily the maximum digging depth for both types of dredges is about forty feet. Some hydraulic dredges have gone to a depth of 120 feet, but as excavation depth increases, additional booster pumps, new hoists, ladder extensions, and more counterweights increase production cost.

Hydraulic dredge production capacity depends on the size and height of the discharge pipe which affects back pressure on the pump, depth below water of the working face, percent of solids drawn in, and pump capacity. The most important factor is the percent of solids drawn in. Except under overload conditions, there is little difference in volume or costs between pumping low and high percent of solids. The limiting factor is the plugging point of the pipe which is lower for less solids and low velocities, especially when working in gravel deposits.

The dredge is one of the most specialized pieces of equipment found in sand and gravel operations and is used exclusively for excavation.

SLACKLINE CABLE



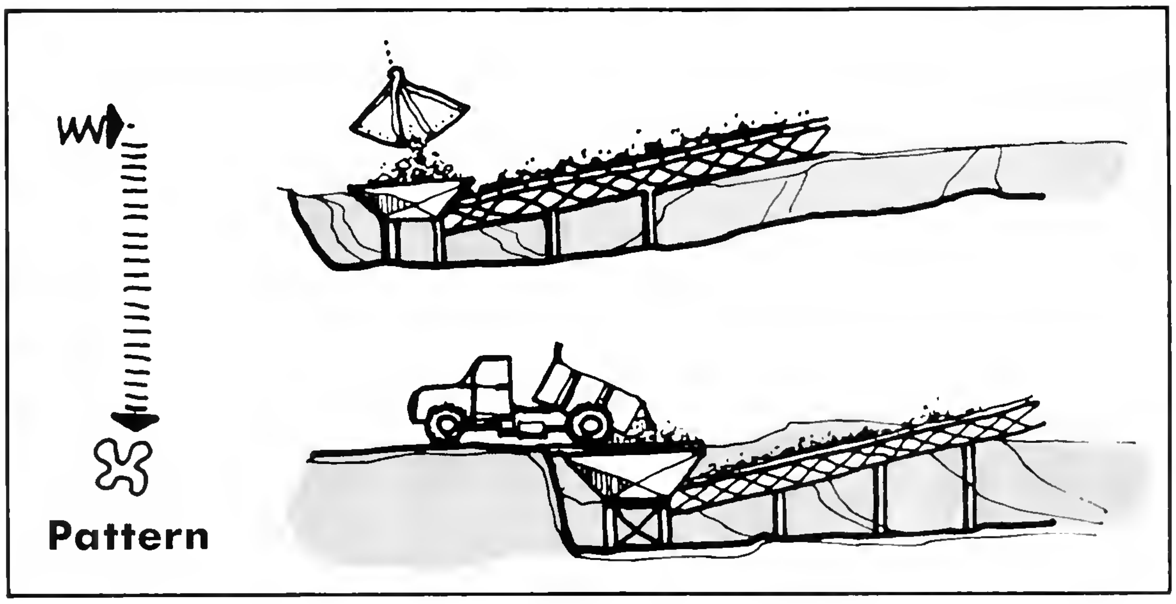
Slackline cables and drag scrapers are the old standby of the mining industry. They are simple, efficient, and reliable, — a bucket between two stations pulled through the deposit. The digging line is changed by moving the tail anchor which eventually leaves a fan shaped pattern similar to the ridges on a brachiopod shell.

The difference between the two types of cable excavation is in the bucket design. The slackline cable bucket has a bottom in it and once it fills with material, it is raised into the air and drawn back to the mast head. The drag scraper bucket is bottomless and when it is full, the cutting edge of the bucket is designed to "float" up, and is dragged along the surface of the ground, back to the mast head.

The average digging span for both models is 300 - 500 feet and bucket capacities range from 1/2 to eight yards. Engines which pull the bucket are gasoline, diesel and electric, and may have as much as 200 horsepower. Slackline cables and drag scrapers have a very slow cycle time when volume per unit of time is compared with other excavating equipment. The drag scraper is the slowest of the two since the ground resistance on the bucket slows the return cycle. Both types work well in homogeneous deposits but when coarse material or boulders are encountered, efficiency drops because the straight digging line reduces the ability to maneuver past such obstacles.

Slackline cables and drag scrapers are used almost exclusively for excavation purposes in a sand and gravel operation.

BELT CONVEYORS



Conveyors are cycling belts used to transport large volumes of loose material along a designated route from a large source. They work well in both flat and hill terrain.

The two basic types are the stationary variety and the semi-mobile equipment attached conveyors.

Stationary conveyors are used to move material over long distances often to convey material from the excavation area to the processing plant located off the site. Conveyors reduce the noise and dust problems of a plant operation in a developed area, by carrying raw materials to the processing plant, which can be located some distance away in the hinterland. The remote location eliminates objections to noise and dust by residents in the general area.

The most common conveyor width is thirty inches. When it is moving at a speed of 450 feet per minute, average for most conveyors, it can transport 520 yards of material an hour. A flat belt conveyor is capable of working on inclines of 28° and with cleats or buckets it can work at slopes of 45° to 90°.

Semi-mobile units may be a complete unit or attached to other pieces of equipment. The direct digging type pulled by crawlers may be used to scoop up windrows of sand and gravel. It is very maneuverable and capable of greater than 90° turns with a total turning radius for most models of 37 feet. The self-propelled paddle loader, a complete unit, eats into surge piles with a rotating motion, conveying the material over the top of the machine, and depositing it into waiting trucks. The bucket loader, a series of buckets on the conveyor belt, operates in the same manner. Both types are excellent for working with stockpiles because of their short cycle time of forty seconds and because of their maneuverability.

Conveyors are used exclusively for carrying material and loading transporting equipment.

DESANDER

The desander, usually associated with wet sites is an item of processing equipment which funnels out excess quantities of sand, sand in excess of market demand. It may be an integral part of the processing plant in which case the waste material, a mixture of sand and water is piped out to waste deposit areas close to the plant area. Some desanders are small semi-portable units which follow excavation, intercept, screen out, and pump the waste sand back into the excavated area enroute to the plant.

Pumping distances may reach 1,200 feet. The characteristic discharge pattern is a flat, five to ten percent, fan of sand.

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